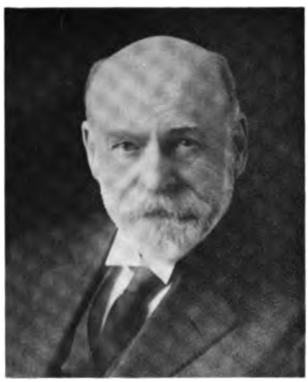


SCHOOL OF MINES COLORADO

FOUNDED 1874

NIL SINE NUMINE

QUARTERLY

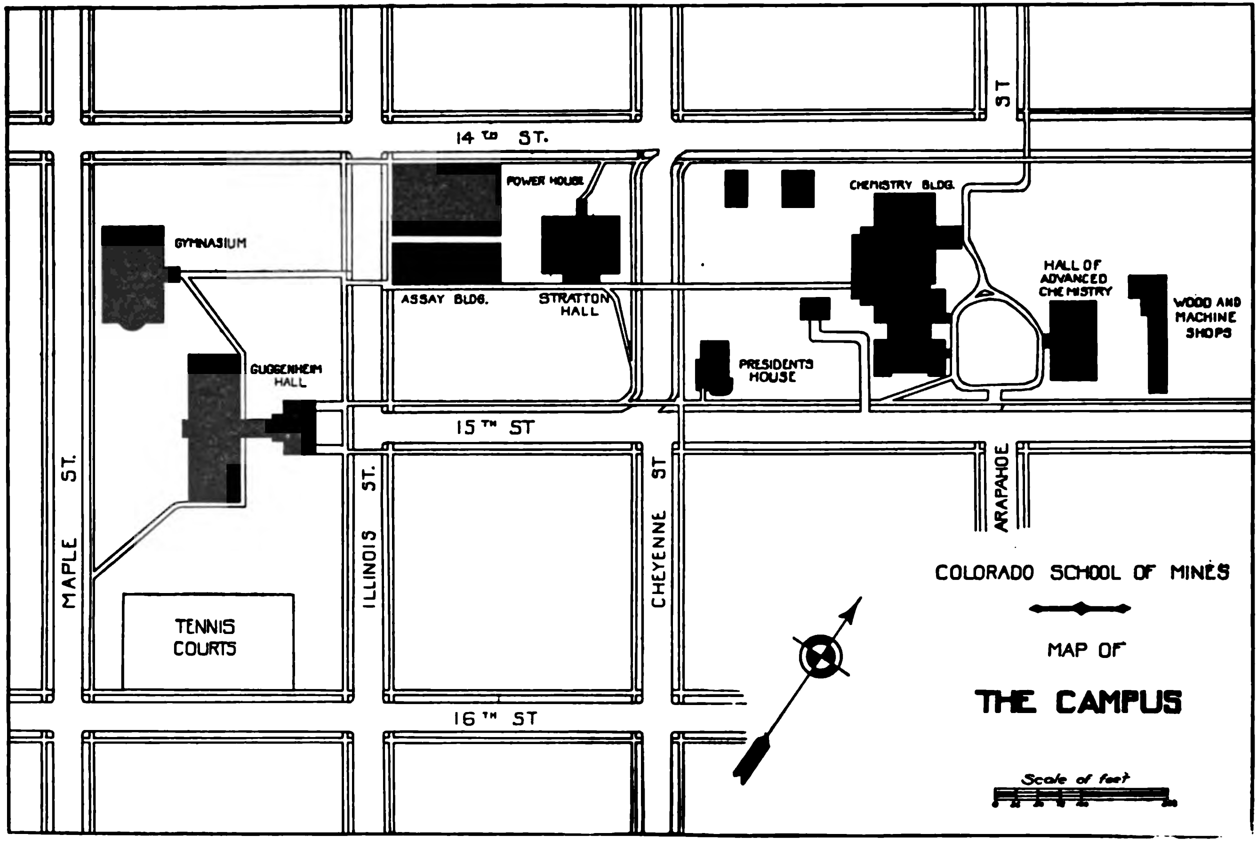
Vol. XVII No. 1

CATALOGUE EDITION

Entered as second-class mail matter July 10, 1906, at the Post Office at Golden, Colorado, under the Act of Congress of July 16, 1894

1

View of Golden from an Aeroplane


COLORADO SCHOOL OF MINES
MAP OF
THE CAMPUS
Scale of feet
14TH ST.
15TH ST
16TH ST
MAPLE ST.
ILLINOIS ST.
CHEYENNE ST
ARAPAHOE ST
GYMNASIUM
GUGGENHEIM HALL
TENNIS COURTS
POWER HOUSE
ASSAY BLDG.
STRATTON HALL
CHEMISTRY BLDG.
PRESIDENTS HOUSE
HALL OF ADVANCED CHEMISTRY
WOOD AND MACHINE SHOPS

QUARTERLY

OF THE

COLORADO SCHOOL OF MINES

Vol. XVII No. 1

Catalogue Edition

GOLDEN, COLORADO
1922

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CALENDAR

1921

November 24, Thursday	Thanksgiving recess
November 25, Friday	
November 26, Saturday	
December 19, Monday	Christmas recess begins
December 31, Saturday	Christmas recess ends

1922

January 28, Saturday	First semester ends
January 30, Monday	Registration for the second semester
January 31, Tuesday	
February 1, Wednesday	Second semester begins
February 6, Monday	Prospector's course begins
February 12, Sunday	Lincoln's birthday—a holiday
February 22, Wednesday	Washington's birthday—a holiday
March 4, Saturday	Prospector's course ends
May 19, Friday	Commencement exercises
May 22, Monday to May 26, Friday	Final examinations
May 26, Friday	Second semester ends
May 29, Monday	Summer field work begins
May 30, Tuesday	Memorial Day—a holiday
July 8, Saturday	Summer field work ends
July 17, Monday	Summer school begins
August 26, Saturday	Summer school ends
August 30, Wednesday	Examinations for entrance to the class of 1926 and re-examination of matriculated students
August 31, Thursday	
September 1, Friday	
September 4, Monday	Registration for the first semester
September 5, Tuesday	
September 6, Wednesday	First semester begins
October 12, Thursday	Columbus Day—a holiday
November 11, Saturday	Liberty Day—a holiday
November 30, Thursday	Thanksgiving recess
December 1, Friday	
December 2, Saturday	
December 21, Thursday	Christmas recess begins

1923

January 3, Wednesday	Christmas recess ends
January 20, Saturday	First semester ends
January 22, Monday	Registration for the second semester
January 23, Tuesday	
January 24, Wednesday	Second Semester begins

BOARD OF TRUSTEES

The regular meetings of the Board of Trustees are held in Golden, at the School of Mines, on the second Thursday of each month.

HONORARY DEGREES

The degree of E. M. (Engineer of Mines) has been conferred as follows:

CAPTAIN E. L. BERTHOUD, 1890
Golden, Colo.
Deceased.

GENERAL IRVING HALE, 1895
Denver, Colo.

A. A. BLOW, 1897
Ware Neck, Va.
Deceased.

FRANK BULKLEY, 1898
Denver, Colo.

JOHN HAYS HAMMOND, 1909
New York, N. Y.

WALTER G. SWART, 1917
Duluth, Minn.

H. G. HARDINGE, 1917
New York, N. Y.

The degree of Sc.D. (Doctor of Science) upon

E. P. MATHEWSON, 1920
New York, N. Y.

FREDERICK LAIST, 1921
Anaconda, Montana

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The Organization of an Oil Company

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Axe Heads or Men

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Fellowship in Industry

FREDERICK RINDGE, Director, Industrial Service Movement, New York, N. Y.
Understanding the Worker

A. H. LICHTY, Vice-President, Colorado Fuel and Iron Co., Denver, Colo.
Employee Representation

C. J. HICKS, Executive Assistant to the President, Standard Oil Company, of New Jersey.
The Business Aspect of Human Relations

KENNETH A. KENNEDY, Vice-President, Banker's Trust Co., Denver, Colorado.
Herbert Hoover, and European Students

HARRY KINGMAN, Pomona College, California
The World Challenge to the Student

E. S. COWDRICK, Assistant to the President, Colorado Fuel and Iron Co., Denver, Colorado
Assaying the Human Raw Element

DR. HARRY F. WARD, Union Seminary, N. Y.
New Motives in Industry

M. W. SMITH, The Duriron Co., Dayton, Ohio
The Story of Duriron

MARTIN J. INSULL, Chicago, Ill., President, Middle West Utilities Corporations

LOCATION, HISTORY, ORGANIZATION, AND FINANCIAL SUPPORT

LOCATION The Colorado School of Mines is in the south central part of the City of Golden, Jefferson County, Colorado. It occupies a plat of approximately twenty-three acres, picturesquely situated about 200 feet above the bed of Clear Creek, at the base of the scenic front range which lies about fifty miles to the east of the main range of the Rocky Mountains. Farther east, about fifteen miles, lies the city of Denver, connected with Golden by three railway lines: the Denver and Intermountain Railroad, Arapahoe Street Station; the Denver and Northwestern Railway, Arapahoe Street Station, or Union Depot; and the Colorado & Southern Railway, Union Depot.

Golden has about twenty-five hundred inhabitants and is one of the oldest cities in Colorado. The altitude is five thousand seven hundred feet above sea level, or about four hundred fifty feet above Denver. The climate is healthy and invigorating with open winters and a large proportion of clear days.

The Colorado School of Mines is particularly fortunate in its natural surroundings and proximity to a rich, practical laboratory. The state of Colorado is famous for its basic industries, the mining of gold, silver, and the baser metals, all of which, together with their allied branches of industry, are highly developed within a relatively small area, of which every part is easily accessible from Golden. In addition, the vanadium, tungsten, uranium, and radium fields are better represented here than in any other part of the world. In view of its great number and variety of mining and metallurgical enterprises, the state offers unexcelled opportunities for practical study.

The school is fortunately situated for the geologist. The surrounding formations not only present the strikingly clear features so characteristic of the west, but also occur in great profusion and variety. In addition, certain features peculiar to this locality afford sufficiently complicated problems to be of great value to the student of geology. It is possible, therefore, without going more than a mile or two from the school, to illustrate effectively most geological problems so that field geology can be carried on at the same time as class instruction.

In the immediate vicinity of Golden are numerous clay mines which produce pottery and fire clay; also lime and stone quarries. Within a few miles are extensive coal mines

well equipped with hoisting and power machinery. Dredging and placer operations have been carried on nearby in Clear Creek.

In Clear Creek canon, a short distance west of Golden, are the historic mining Camps of Central City, Black Hawk, Idaho Springs, Silver Plume, and Georgetown. The ores of this district vary from free milling gold quartz to complete silver-lead-zinc ores.

Farther west is the camp of Breckenridge, where placer mining is carried on, and the mining camps of Montezuma, Kokomo, and Robinson. To the southwest are the famous Leadville and Alma districts, well known for rich lead and zinc ores. West of Leadville is the renowned silver mining camp of Aspen, and to the north of Leadville is the lead-zinc camp of Gilman.

At Denver are located a number of large plants manufacturing mining and milling machinery. Here also are the Western Chemical Manufacturing Company, producing acids and electrolytic zinc, and the Denver Mint, where gold and silver are refined by electrolysis.

West of Colorado Springs is located the Golden Cycle Mill, which treats ore from the Cripple Creek district. Farther west are the prominent camps of Victor and Cripple Creek, in which are located some of the famous gold mines of the world. Near Victor is the well known Portland mine and mill, where low grade Cripple Creek ores are successfully treated.

The plant of the Colorado Fuel and Iron Company, at Pueblo, is the largest concern, west of the Mississippi, producing iron and steel. At Pueblo are located the Pueblo plant of the American Smelting and Refining Company; and the zinc smeltery of the United States Zinc Company. At Canon City is the plant of the Empire Zinc Company, and at Leadville the Arkansas Valley plant of the American Smelting and Refining Company.

In the southwestern part of Colorado is the famous San Juan mining district, which includes the well known camps of Ouray, Telluride, Silverton, and Lake City, where many great mines are located and some of the most efficient milling plants in the world are to be found.

Coal mining is well represented in Colorado by the bituminous mines of the northern coal fields, the anthracite fields of Glenwood Springs, the coal fields of Trinidad, and numerous smaller fields. Oil fields are being developed and operated at Florence, at Boulder, and in Routt County. Development of the structures in the eastern part of the state are being undertaken.

At Florence is the oil refining plant of the Continental Oil Company; also the works of the River Smelting & Refining Company producing zinc-lead pigment.

The oil shale deposits on the western slope, in the region of Debeque and Grand Valley, are the largest and richest in the world. Pioneer work in development of the industry is now under way in this locality. A deep interest is taken at the School in the development of this new industry.

Easily accessible on the north are the large oil fields of Wyoming, and the refineries operated by the Midwest Refining Company, and the Standard Oil Companies.

Many prominent mining camps in neighboring states are easily reached from Golden. Among these are the great copper districts of Montana, Utah, and Arizona, where the latest mining, milling, and smelting operations are in progress: the iron mines of Wyoming; and the gold mining camps of South Dakota.

No other mining school in the world has within easy access such a wide variety of mining properties, or such excellent opportunities for observing the latest and best milling and smelting operations.

HISTORY The Colorado School of Mines was established by an act of the Territorial Legislature, approved February 10, 1870. Since that time the School has enjoyed a strong and steady growth in buildings, in equipment, in students, in faculty, and in the strength and rigor of its courses. Additions were made to the original buildings in 1880, by the building of 1882, and by the building of 1890, all of which are now united and called the Hall of Chemistry. The Hall of Advanced Chemistry was erected in 1894, the Assay Laboratory in 1900, and Stratton Hall in 1904. The Heating, Lighting, and Power Plant was completed in 1906. The Administration Building, named Simon Guggenheim Hall for the donor, was also erected in 1906. The Gymnasium was completed in 1908. The Experimental Plant was completed in 1912.

ORGANIZATION The general management of the School is vested by statute in a Board of Trustees, which consists of five members appointed by the Governor of the state, with the advice and consent of the Senate. The members of the Board of Trustees are appointed in alternating sets of two and three, and hold their office for a period of four years and until their successors are appointed and qualified. The Constitution of Colorado recognizes the School of Mines as an Institution of the State.

FINANCIAL SUPPORT The Colorado School of Mines is supported by the income derived from an annual mill tax of the state. This is known as the "School of Mines Tax."

BUILDINGS

SIMON GUGGENHEIM HALL Administration Building This building, the gift of Ex-Senator Simon Guggenheim, was erected and furnished at a cost of $80,000. The cornerstone was laid by the A. F. and A. M. of Colorado, October 3, 1905. The first floor is devoted entirely to the department of geology, and includes lecture room, laboratory, offices, two work rooms, and a public museum; the second floor contains the library, the offices of the President, Dean, and Registrar, the Faculty and Trustees' room; the third floor contains the Assembly Hall, two lecture rooms and offices. The building was dedicated October 17, 1906.

HALL OF CHEMISTRY. This is a continuous group of brick buildings which comprise the buildings of 1880, 1882 and 1890. The combined buildings of 1880 and 1882 contain the main inorganic chemical laboratories. In the building of 1890 are the main office and the private laboratories of the professors, the chemical lecture room, the chemical store room, the physics laboratory, three recitation rooms, the laboratories for gas, fuel, spectroscopic analysis and physical chemistry, and the freshman and sophomore drawing room.

HALL OF ADVANCED CHEMISTRY. This building, constructed of red pressed brick, consists of two floors and basement, and was completed in 1894. It contains the petroleum and shale oil laboratories, the metallurgical chemical laboratory; and the laboratories for organic and industrial chemistry; also the wireless telegraph station, the laboratory for civil engineering, the metallography laboratory, and private research laboratories.

ASSAY BUILDING This building was built in 1900 with funds contributed by the late W. S. Stratton, and enlarged in 1905. The design and equipment of this building make it probably the best of its kind in the country.

GYMNASIUM This building, costing $65,000, was completed in September, 1908. The first floor contains a large swimming pool, shower baths, and locker room, finished in white marble and tiling. The second floor contains the offices of the athletic director; the Latin-American Club room; the Theta Tau and Tau Beta Pi room, and the Integral Club room. The entire third floor is occupied by the gymnasium proper. This contains fifty-two hundred square feet of clear floor space and a balcony.

STRATTON HALL The corner-stone of this building was laid by the A. F. and A. M. of Colorado, on November 20, 1902, the building was completed in January, 1904. The first floor contains two large lecture rooms, each with apparatus room and private office. The second floor accommodates the surveying, mechanics and electrical engineering lecture room, private office, and the R. O. T. C. room. The third floor is devoted entirely to a large drafting room for the junior and senior classes. The basement contains laboratories for metallurgy and electrical engineering. The structure was named in honor of the late W. S. Stratton, who contributed $25,000 toward its cost.

HEATING, LIGHTING, AND POWER HOUSE The power plant, erected at a cost of $40,000, is designed to furnish light, heat, and power to the entire school. It is a simple but artistic brick building, eighty-three by one hundred twenty-two feet, with concrete floors and tile roof. The building is divided lengthwise into an engine room thirty-four feet wide, and a boiler room forty-five feet wide. A brick-lined steel stack one hundred twenty-five feet high carries all smoke to the upper air and away from the buildings.

EXPERIMENTAL PLANT This building, erected in 1912, was made possible by an appropriation of $100,000 by the legislature of Colorado. It is situated a short distance from the campus, on the bank of Clear Creek. It is intended to be not only a laboratory for the use of the students in ore dressing and metallurgy, but also a testing plant for the benefit of the mining industry. It is the largest and most complete plant of its kind in the United States.

THE STATE ARMORY The school has leased from the State Military Board the N. G. C. Armory, which will be used, as needed, for a supplementary drill hall, dormitory, mess hall, and infirmary, as occasion requires.

RESIDENCE OF THE PRESIDENT This is a brick building of two and one-half stories. It was built in 1888.

CARPENTER SHOP This is well equipped for the special demands which are continually arising in a technical school. The work varies from ordinary repair work to the careful construction of special apparatus needed in the various laboratories.

MACHINE SHOP This contains the necessary machinery for the maintenance and repair of equipment, and also for the construction of such apparatus as is required for carrying on any new or original work

LABORATORIES AND EQUIPMENT

THE EXPERIMENTAL ORE DRESSING AND METALLURIGICAL LABORATORY

The Building The plant is situated on the bank of Clear Creek, a few blocks from the campus of the school. The building is ninety-eight by one hundred forty-one feet eight inches on the ground floor. The framework is of structural steel resting on concrete foundations which have been carried down to a substantial bed of gravel. The walls consist of two and one-half inches of cement mortar, reinforced by "hy-rib," and are of natural cement color. The roof is of elaterite resting on a two-inch sheathing of matched Oregon fir. The ground floor is concrete and is divided into three benches. Above the ground floor, but covering only a part of the area, are two suspended floors of reinforced concrete, supported by steel framework. The building is well lighted, heated, and ventilated.

Power All machinery and apparatus requiring power are operated by alternating current motors supplied with current from the power house. For the generation of the current required, a producer gas-power generator unit of 100 kv-a. capacity has been installed in the power house. This unit is of Westinghouse design and consists of a bituminous suction gas producer, a vertical three-cylinder gas engine, and a direct-connected alternating current generator. The producer has a number of noteworthy features The principal one, and the one which contributes so largely to its success, consists of the two distinct fire zones. This feature makes it possible to operate successfully on very low-grade fuel, and eliminates the difficulties usually arising from the tar and hydrocarbons given off and deposited during the process of gas making. Ordinary Colorado lignite coal is used. From this is produced a cool, clean gas with a heat value of from 115 to 130 B.t.u. a cubic foot. To eliminate the loss of power on account of a reduced intake pressure, a motor-driven, positive-pressure type of exhauster is used. This draws the gas from the producer and delivers it to the engine at a pressure corresponding to about four inches of water. The engine is of the standard Westinghouse vertical three-cylinder, four-stroke cycle, single acting type. The cylinders are 15-inch diameter by 14-inch stroke. At a speed of 257 revolutions a minute the engine, operating on the producer gas, delivers 118 b.h.p. Compressed

air is used for starting, and both engine and producer can be started readily, even though they have stood idle for several days. Direct connected to the engine through a spring coupling is a 100 kv-a, 2,300-volt three-phase, 69-cycle generator. The current is transmitted at this voltage to the plant, where it is stepped down to the working voltage of 440. The installation is such that the 100 kv-a. machine can be operated in parallel with a steam turbine in the power house. In case of an emergency all power can be applied from the turbine alone. Another source of power is available through switches which connect the school power system with that of the Jefferson County Power and Light Company.

The plant is provided with both large and small scale equipment which can be used for the following:

1. Sampling; 2. Wet Concentration; 3. Flotation; 4. Roasting; 5. Cyaniding; 6. Magnetic and electrostatic separation; 7. Electro-metallurgical processes; 8. Chemical and metallographic work; 9. Oil Shale.

The following is available:

Preliminary Testing. (Using from 10 to 75 pounds of ore.)

- 30 inch Wilfley table with two decks having different styles of riffling.
- Small Richards pulsating jig.
- Small Richards pulsating classifier.
- Automatic feeder.
- 6 by 48 inch amalgamating plate.
- 3 by 5 inch Plumb pneumatic jig.
- Callow miniature flotation set including rougher and cleaner cells.
- Air lift and Pachuca tank.
- Small Jones flotation cell.
- Small Butchart flotation machine.
- Several flotation cells of the Minerals Separation type.
- Small scale cyanide layout.

Intermediate Testing. (Using 100 to 1,000 pounds of ore.)

- Quarter sized Wilfley table.
- Several jigs.
- Small Card table.
- Small Butchart table.
- Flotation machine.
- Oliver filter.
- 2 ft. Hardinge ball mill.
- Dorr classifier.
- Quarter size Deister-Plato table.
- Aikens classifier.
- Richards jig.

Large Size Testing. (Using 5 tons to a carload of ore.)

Sampling.

Scales, Gates gyratory and Blake crushers, Vezin and Brunton samplers, rolls and bins.

Wet Concentration.

Fine crushers, elevators, trommels, jigs, regrinders for middlings, classifiers, sand pumps, tables, and slimers.

Amalgamation.

Stamps, plates, classifiers, tables, and slimers.

Cyaniding.

Dorr classifier, tube mill, Dorr slime thickener, sand leaching tank, mechanical agitation tank, Patterson circulation treatment tank, pumps for sand, slime, solution, and vacuum; Moore filter, Butters filter, zinc boxes, and lead lined acid dissolving tanks.

Magnetic Separation.

One Dings two magnet separator.

Magnetic Roasting.

One Wilfley annular hearth revolving roaster, one hand operated reverberatory type roaster, one hand operated muffle type roaster, and pyrometers for recording temperatures.

Electrostatic Separation.

Huff electrostatic current producing devices.

One separator for fine material.

One separator for coarse material.

The Experimental Plant is so designed as to facilitate the work of preparing flow sheets for prospective ore dressing plants.

ORE TESTING ARANGEMENTS Three different proposals for the use of the plant are ofered:

A. Any responsible person, or organization, may, with the consent of the Director, use the equipment by paying for the actual material, labor, power, water, expert assistance used, and depreciation. In this case the person using the plant is responsible for the accuracy of the results obtained.

B. The director of the plant and his assistants will conduct a test, in which case a charge equal to the cost of similar work done by a commercial testing plant or by a consulting engineer will be made. If desired, the director will make an estimate of the cost previous to starting the work, but this will not be used in billing the actual charges. The director will be re-

sponsible for the accuracy of the results, and will make a report to the person authorizing the test without stating that the ore comes from any particular mine or locality, unless he supervises the arrangements for taking the samples. The director will not suggest suitable devices nor recommend machines put out by the various manufacturers for the commercial plant that will subsequently be built as a result of his test work. The person receiving the report of the test work should employ a consulting engineer to advise further in regard to the building of a commercial treatment plant.

C. A person or organization desiring to conduct a prolonged research may establish a fellowship at the school under the director, to cover a period of one year or longer, and the fellow may give all or a part of his time to the special research work. In the latter case, the greater part of his time will be devoted to the special research and the remainder to post graduate study. The person establishing the fellowship will pay the salary of the fellow and the actual cost of material, labor, power, water, and depreciation necessary for the research work. The director and his staff will supervise the work of the fellow without charge, will assume the responsibility for the accuracy of the results obtained, and will make a complete report of the work performed. This will not be published for a period of two years without the consent of the person establishing the fellowship. Patents to cover any part or all of a process developed by the fellow under this agreement will be assigned to the person establishing the fellowship.

Ore Shipments. Ores may be shipped by express or freight directly to Golden, Colorado, all charges prepaid. Freight sent via the Colorado & Southern Railway or via the Denver & Intermountain Railway must be hauled by wagon from the railroad yards to the testing plant at the expense of the shipper. All details as to responsibility of the shipper, suitable modes of making payments, size and handling of shipments, nature of testwork to be carried on, the persons to whom reports are to be made, and other necessary business details should be clearly understood, as a result of correspondence or conference with the director before consignments of lots of ore of any size will be authorized.

COLLECTION OF COMMERCIAL ORES Most collections of ores are classified according to their mineral contents, but the department of mining is pursuing the policy of gathering average ore samples from every mining district. These are arranged geographically so that the typical ores of each mining district are placed together. Such an

arrangement is found to be of great educational value to the classes in mining. The collection now numbers about 1,400 specimens. A considerable number of specimens from large Arizona and California mines has been added recently.

MINERALOGICAL AND GEOLOGICAL LABORATORY AND CABINET Under the name cabinet is embraced not only the display collections, which may perhaps be called the cabinet proper, but also the other collections that have been prepared mainly for the purpose of class instruction. These collections are necessarily changing from year to year, as new material is constantly being added. This new material is obtained partly by purchase, but mainly by direct collecting, by gifts, and by means of exchange with other institutions. The display collections are arranged in different cases with a view to displaying certain groups of minerals, or minerals from certain localities. The various collections, which together contain sixty-six thousand specimens, consist of display, type, and working or study collections of minerals, fossils, rocks, and ores. The rock collections include a general collection from different countries, one devoted to Colorado localities, and still others that cover particular countries or localities.

MINERALOGICAL LABORATORY Aside from the special advantages of location, the department of geology is well equipped for practical teaching. The entire first floor of Guggenheim Hall is occupied by this department. The south end of the building is occupied by a commodious lecture room, with a seating capacity of more than a hundred, and by a separate mineralogical laboratory with table space for between fifty and sixty students, also by two small recitation rooms. On the extreme north end of the building is the public museum, devoted to a display of fine minerals. Additional space is provided for working rooms, office, packing, and storage rooms.

TESTING LABORATORY This laboratory is provided with a motor-driven 100,000-pound Riehle testing machine arranged for experiments in tension, compression, shearing, and flexure of materials, and extensometers for measuring deformations. The equipment for cement testing includes a 2,000-pound Riehle testing machine, and a 2,000-pound Olson automatic shot machine for testing briquettes in tension, Le Chatelier apparatus, fineness sieves, and a set of sensitive balances for the fineness test and for other exercises, trowels, spatulas, large slate mixing boards, desks with glass tops, molds, damp box immersing vats, and other accessories.

ELECTRICAL LABORATORY This laboratory is equipped with standard makes of voltmeters, ammeters, and wattmeters, inductive and non-inductive resistances for artificial loads, a Thomson apparatus for induction experiments, a slip indicator for induction motors, an automatic speed recorder which can be used for finding the acceleration curves of motors, an Alden absorption dynamometer for motor testing, a contact apparatus for alternating current and voltage wave form, and a split phase rotary field apparatus. The generators available for laboratory work include a 100 kv-a, 2,300 volt, 60 cycle, 3-phase Westinghouse alternator, driven by a Westinghouse producer gas engine, a 75 kw. 230 volt, 3-wire, d.c. Westinghouse generator, driven by a 112 h.p. 2,300 volt, 3-phase, synchronous motor, a 75 kw. Bullock twin unit continuous current generator set, driven by a 110 h.p. De Laval turbine, a 30 kw. 1,100 volt, 125 cycle, single phase General Electric alternator, a 15 kw. 130 volt compound, continuous current generator designed and built at the school, an 8 kw. Crocker-Wheeler generator, a 6 kw. 130 volt Westinghouse generator, a 7.5 kw. 125 volt compound machine, a ·3 kw. 5 and 10 volt electrolytic generator, a small single phase rotary converter, a 2 kw. 120 volt compound Brush machine, a series arc light machine, and a small Edison shunt generator. The Bullock generators can be connected at the switchboard to supply the 120-240 volt 3 wire lighting and power circuits, or they can be put in parallel and thus supply more than 600 amperes for electrothermic work. The motors include a 10 h.p. 220 volt, 60 cycle, 3-phase constant speed induction motor of General Electric make, two 7.5 h.p. 220-volt, 60-cycle, 3-phase induction motors of the Fairbanks, Morse & Company make, two 5 h.p. series motors with controllers, a 5 h.p. 3-phase, two-speed induction motor, used for electric drilling, a 4 h.p. single-phase Wagner motor, a 400-2,000 rev. per min. adjustable speed experimental motor designed and built at the school, a 20 h.p. series motor, and a large number of 3-phase motors and shunt machines of standard makes in daily use about the shops and buildings. The storage batteries of 54 cells each are in daily use and are available for study. In addition to these generators and motors, a modern 5 panel d.c. switchboard and 7 panel a.c. and d.c. switchboard with the usual instruments, switches, and auxiliaries, afford excellent opportunities for the study of electric plant equipment. The engine room is utilized as a part of the dynamo laboratory, but the laboratory in Stratton Hall, equipped with numerous circuit outlets and portable instruments, is used chiefly for the study of motors and their auxiliaries. At present there are 78 generators and

motors available for study. Transformers up to 80,000 volts are in use.

SURVEYING EQUIPMENT The equipment of the department for surveying is well adapted to the practical course given. For transit work there are thirty light mountain transits, of which fifteen are equipped for underground surveys. There are also ten heavy transits, one of which is of English and one of German make. In addition to the transits there are ten plane tables for taking topography. For leveling, there are seven wye levels and five dumpy levels of standard manufacture. The department is well supplied with leveling rods of various makes and types, stadia rods, tapes, hand levels, pocket transits, range poles, and other accessories. The instruments are manufactured by such well known firms as C. L. Berger & Sons, Buff & Buff, Heller & Brightly, Eugene Dietzgen & Co., Peter Herr & Co., W. and L. E. Gurley, Keuffel & Esser, William Ainsworth & Sons, Weiss & Heitzler, Young & Sons, Negretti & Zambra (English), Max Hildebrand (German), and A. L. Leitz.

CHEMICAL LABORATORIES The laboratories for general chemistry and qualitative analysis are on the first floor of the Hall of Chemistry. They are equipped with 126 specially designed tile topped desks, each provided with gas, water, filter pumps, porcelain sinks, low reagent shelves, and individual lockers. There are two fully equipped lockers to each desk, which provide for 252 students, in two sections. These laboratories are ventilated by a newly installed exhaust system that effects a complete change of air every four minutes, combined with pure hot air intakes for cold weather. Gas is supplied to the laboratories by a 300-light Detroit gas machine connected with gasoline supply tanks buried outside the building. The sophomore quantitative laboratories are on the second floor. They are equipped with both tile and asbestos topped desks, duly provided with lockers, gas, water, filter pumps, and reagent shelves, and can accommodate 134 students working at the same time. The room ventilation is an exhaust system, in addition to which there are large and well drawing hoods, fully equipped with large electric hot plates and gas. Blast lamps and electric furnaces and drying ovens are also conveniently at hand. The balance rooms contain 30 balances of leading makes.

There are several specially equipped smaller laboratories for electro-analysis, fuel and gas analysis, photography, and spectroscopic analysis. A special laboratory for students in

technical ore analysis is provided with desks for 48 students, working in two sections. The equipment of this laboratory is especially complete, in order to familiarize the students with the methods necessary in rapid commercial work. Each desk has gas, water, and sink connections, and filter pump. In addition to this, each desk is provided with a perfectly working individual hood, which ensures pure air in the laboratory at all times. The main physical chemistry laboratory is a large room, well equipped with the apparatus necessary for the course, together with special equipment and facilities for radio-active work. The reserve supplies of chemicals and apparatus for all the laboratories are kept in large well filled stock rooms. There are four private laboratories for the professors in charge. These are completely equipped with water, gas, steam, compressed air, electric furnaces, drying ovens, and hot plates. They serve for research, the study of analytical methods, and the checking of results. Small laboratories are provided for the preparation of special reagents and stock solutions. The Hall of Advanced Chemistry contains the petroleum and shale oil laboratories. They are well equipped for all the requirements of the commercial testing of shale and petroleum products, and are also especially fitted for research work. The laboratories for in-industrial and organic chemistry are in this building, and also the junior laboratory for advanced quantitative analysis. The latter is provided with desks and lockers for 64 students, and has all necessary equipment, besides electric combustion furnaces for iron and steel work. Twelve small laboratories, distributed through the Hall of Chemistry and the Hall of Advanced Chemistry, are equipped and reserved for research work by advanced students and post graduates

PHYSICS LABORATORY The physics laboratory is in the basement of the Hall of Chemistry. It is a large, well lighted room forty by sixty-five feet. It has a high ceiling, is well ventilated, and accommodates fifty students at one time. Most of the equipment is new. In the equipment is found micrometer gauges, vernier calipers, protractors, spherometers, pendulum apparatus, moment of inertia apparatus, Jolly balances, beam balances, calorimeters, specific heat apparatus, coefficient of expansion apparatus, Boyle's law apparatus, accurate resistance boxes of different ranges, contact keys, Wheatstone bridges, Post Office bridges, Kohlrausch bridges, potentiometers, Kelvin bridge, coulometers, standards of resistance, capacity, inductance, and E. M. F., optical benches, spectrometers, sound apparatus, voltmeters, ammeters, and wattmeters. The laboratory is supplied with electrical energy of dif-

ferent voltages from storage batteries and power house, and also has gas and water supply. It is a well equipped laboratory especially adapted to engineerihg education.

MECHANICAL ENGINEERING LABORATORY The heating, lighting, and power plant is well equipped for mechanical engineering laboratory practice. The boiler room contains the following principal equipment. One 200 h.p. and one 100 h.p. Babcock & Wilcox water tube boilers, each equipped with a chain grate; one 80 h.p. tubular boiler equipped with plain grate; Green Engineering Company fuel economizers; Babcock & Wilcox independently fired superheater; Webster feed water heater, boiler feed and vacuum pumps and injectors; one Wilcox water weigher; a 125 by 5-foot self supporting steel stack supplemented by a steam driven 42-inch Sirocco fan for induced draft; eight 25-ton steel bunkers for coal storage; and a 125 h.p. Westinghouse doubleflow gas producer equipped with wet and dry scrubbers, mixing and gas storage tank, and motor driven exhauster. The engine room contains the following apparatus: 10 by 12-inch high speed Russell engine; 6 by 9-inch throttling Sturtevant engine; 75 kw. De Laval steam turbine geared to twin generators; 7 by 6-inch two cylinder vertical Westinghouse Jr. engine; Webster feed water heater and purifier; one alternating and three direct current generators; modern switchboard equipped with high-grade instruments; 15 by 14-inch three cylinder vertical Westinghouse gas engine direct connected to alternator; 6.75 by 14-inch Fairbanks, Morse & Company gas engine; 8.75 by 14-inch Priestman oil engine; a Studebaker four cylinder automobile motor; a J. George Leyner Engineering Works two stage air compressor, capacity 275 cubic feet of free air per minute; and a small Westinghouse air-brake; a series of steam radiators equipped with thermometers, gages, and condensate tanks for testing steam heating apparatus; full sized model of aerial tramway equipment, with buckets, carriages, cables, rails, and tripping mechanism. The laboratory is well equipped with auxiliary apparatus such as indicators, reducing motions, tachometers, gages, prony brakes, calorimeters and manometers, for conducting experimental work.

METALLURGICAL LABORATORIES. These laboratories are equipped with apparatus for the study of the quantitative relations of the various agencies occurring in metallurgical changes. The equipment includes the Junker, Mahler-Bomb, and Parr calorimeters; the Wanner optical, Fery radiation, Le Chatelier and Bristol electrical pyrometers, a Leeds and Northrup

Hump Method Heat Treatment electric furnace, with Curve Drawing Recorder; several small electric furnaces; a Hoskin gasoline furnace; and the miscellaneous apparatus usually found in metallurgical laboratories. In the metallography laboratory there are five polishing machines, seventeen metallographic microscopes, a camera for taking microphotographs, a power hack saw for cutting specimens, and a Brinell hardness machine. In the flotation laboratory there are examples of the following types of flotation machines, all power driven: Callow Pneumatic, Minerals Separation, Jones, Ruth, Janney, K. & K., and Butchart. There is a laboratory size ball mill, a Rotap machine, with the necessary screens for making screen analyses; and apparatus for chemical analysis. Complete equipment is available for the study of the electrolytic recovery and defining of metals. Provisions for large scale work is made in the Experimental Plant.

METALLURGICAL COLLECTIONS The School has a fine collection of models from the works of Theodore Gersdorf, Freiberg, Saxony, which illustrate types of furnaces in this and other countries. Each model is made to scale and is complete in every detail. In addition to these models are the following to illustrate the best modern practice: working model of a twenty stamp mill, on a scale of one and one half inches to the foot; working model of crushing rolls; working model of a Dodge crusher; model of modern blast furnace for lead-silver ores, with water jackets; smaller models, such as the complete set used in the famous Keyes and Arents lead-well suit. There is also a large collection of ores, ore dressing, and metallurgical samples and products.

ASSAY LABORATORY. This laboratory is divided into furnace room, parting room, balance room, store room, and office. The furnace room is equipped with thirty-two coal fired muffle furnaces, six Case distillate furnaces, one gasoline furnace, two Iler cupel machines, and a pair of bullion rolls. In order to avoid dust, change of temperature, and direct sunlight, the balance room has no outside walls, and is lighted by means of a skylight. The weighing equipment includes five gold balances, six silver balances, and seven pulp balances. Several of these are new, and most of the others have recently been repaired. Nearly all of the standard makes are represented and the students are thus made acquainted with the various types. Each student has his own muffle and coal bin, or oil supply, and a separate working desk and locker, in close proximity to his furnace.

MINING LABORATORY AND MINE CAMP. The mining laboratory work is done at the Mine Camp at Idaho Springs, Colorado. The School has leased the upper workings of the Edgar mine for mining operations, and also has the privilege of using other portions of the mine for mine surveying. The workings on the property offer an underground surveying problem including tunnel, drift, and shaft, which, with the surface lines, make a closed traverse of about two miles. In detail this traverse is as follows:—

The Edgar vein is cut at a depth of 625 feet by the Miami tunnel at a distance of 1,950 feet from the portal of the tunnel. The Miami is a cross cut tunnel in schist of the Idaho Springs formation, and before reaching the Edgar vein proper, intersects seven well defined veins, and several small fissures. Two interesting dikes of Bostonite and Monzonite porphyry respectively, are also exposed in the tunnel; the contact on both walls is clearly shown. From the point of intersection of the Edgar vein and Miami tunnel a drift extends westerly 270 feet to a cross cut driven about 20 feet to the south. From here a winze extends 200 feet to a blind level below. This level at 70 feet reaches a manway, thence 80 feet to the tunnel level of the Edgar below. This level is 900 feet to the Big Five tunnel through which the surface is reached at a distance of 2,500 feet.

The surface ground above the tunnel has just the topography needed for Mineral Land Surveying. Here lode claims can be laid out with discovery shafts on actual lines and ties made to U. S. Government triangulation stations, mineral monuments, and section corners. This ground is traversed by numerous dikes which can be studied in relation to mining operations. The lower ground along Clear Creek and its numerous tributaries affords opportunities for placer and mill site surveying. In addition to the surveying problems the Edgar vein and the numerous veins cut and drifted on in this Miami tunnel afford opportunities for mine sampling, work in mining geology, drifting, sinking, raising, stoping, timbering, in fact all the mining operations possible in a small mine. Electric power and compressed air can be supplied at any point.

The Colorado School of Mines also has the privilege of surveying and studying the Big Five tunnel, more than 10,000 feet in length, the Newhouse or Argo tunnel, 21,000 feet in length, and the many mines developed by these tunnels. They also have the access to practically every mine in the neighborhood. Opportunity for inspection trips of all kinds, and for working out nearly all possible problems in connection with mining operations

is afforded the School by the tunnels, mines, and metallurgical plants of the Idaho Springs district.

The equipment consists of numerous drills which are taken apart, reassembled, and used by the student; forges, anvils and tools for blacksmithing; the air receiver, valves, gages, fuses and switches connected with the compressed air and electric power transmission; two mining cars; materials for track laying, and all other supplies usually found at a tunnel house. Among the makes of rock drills used by the students are Rand, Ingersoll, Sergeant, Leyner, McKiernan, Wood, Hardsocg, Shaw, Ingersoll-Leyner, Dreadnaught, Waugh, and Temple-Ingersoll. All of the mountings, such as bars, tripods, and arms, and a supply of drill steel, are also provided. For the measurement of air consumption in drilling operations, the Clark, Drillometer, and displacement meters are installed. Batteries, galvanometers, and rheostats are provided in connection with electric shot firing. In the laboratory at the school are two working sized models of the Bleichert system of aerial trams; numerous models of mines; an explosive tester; a collection of rock cores taken by diamond drills; models of timbering methods; many mine maps; instruments for measuring ventilation; lantern slides illustrating mining operations; samples of wire ropes and drill steels; lamps of the open and safety patterns; a dry placering machine; and many photographs of mines and operations.

FRESHMAN AND SOPHOMORE DRAWING ROOM This occupies the upper floor of the Hall of Chemistry. The floor area is about four thousand square feet. Each student is provided with a drawing table, a drawer, a drawing board, and a stool. The present equipment accommodates about one hundred thirty-five students. There are many models to aid the students in their work.

JUNIOR AND SENIOR DRAWING ROOM The entire third floor of Stratton Hall is used for the junior and senior drawing. The room is 60 by 90 feet. Each student is provided with a drawing table, a drawing board, and a stool. Most of the drawing tables are independent and adjustable. The present equipment accommodates about 110 students. There is a blue print room fully equipped with an adjustable printing frame and all other necessary appliances. There are for the use of the students a large number of blue prints from industrial corporations.

REQUIREMENTS FOR ENTRANCE

FRESHMAN CLASS

Unit Course. A unit course of study is defined as a course covering a school year of not less than thirty-six weeks, with five weekly periods of at least forty-five minutes each.

Fifteen units are required for entrance, of which eight are specified and seven may be chosen from a list of electives.

Specified Units

Essentials of Algebra	1	unit
Advanced Algebra	½	unit
Plane Geometry	1	unit
Solid Geometry	½	unit
English	3	units
History	2	units
Specified Units	8	
Elective Units	7	
Total Units for Entrance	15	

Elective Units

The seven elective units may be selected from the following list: Chemistry, Physics, Drawing, Shop Work, Mathematics, Latin, Greek, French, Spanish, History, English, Science, Psychology, Political Economy. In allowing credit for drawing and shop work two forty-five minute periods will be regarded as equivalent to one forty-five minute period of classroom work. Half units are accepted in all studies except in physics and chemistry, provided that not less than one full unit shall be accepted in language. Students are advised to take Chemistry and Physics during their high school course.

Entrance

(a) By Certificate.

A graduate of an accredited high school in the State of Colorado will be admitted without examination upon the presentation of proper credentials from the principal of his high school, provided that the studies he has successfully completed cover the requirements for entrance. Blanks for this purpose will be sent, on application to the Registrar.

Graduates of accredited high schools in other states will be accepted in the same manner as graduates of accredited high schools in Colorado.

(b) By Examination.

All other candidates for admission will be required to pass entrance examination. These examinations are held in Golden.

For the benefit of any student who cannot take the examination in Golden conveniently, on account of the distance, arrangements will be made so that he may take the examination under the direction of some responsible person at his own home, or near it.

Entrance examinations for the class of 1925 will be held in Golden on Wednesday, Thursday and Friday, August 30, 31, and September 1, 1922.

It is the opinion of the Faculty of the Colorado School of Mines that every candidate for the freshman class should have taken a thorough course of at least four years in a good high school, or its equivalent, and during the last year of his preparation should have had a thorough review of mathematics. Special attention should be given to the preparation in chemistry, physics, and mathematics. **It is contrary to the policy of the school to admit a student under condition, or to admit special students. Those who enter are expected to take the regular course and to become candidates for a degree.**

REGISTRATION

The first Monday and Tuesday of September are the registration days for the first semester; and the first two days of the second semester are the registration days for that semester. A fee of one dollar is charged for registration later than the days assigned for registration.

DESCRIPTION OF THE UNITS REQUIRED FOR ENTRANCE

ENGLISH (3 Units)

(a) **Grammar** The student should have a sufficient knowledge of English grammar to enable him to point out the syntactical structure of any sentence which he meets in the prescribed reading. He should also be able to state intelligently the leading grammatical principles when he is called upon to do so.

(b) **Reading** The books prescribed by the Joint Committee on Uniform Entrance Requirements in English form the basis for this part of the work.

The list is divided into two parts: the first consists of books to be read with attention to their contents rather than to their form; the second consists of books to be studied thoroughly and minutely.

The lists thus divided are as follows:

I Books prescribed for reading

Group I (Two to be selected)

Shakespeare's *As You Like It, Henry V, Julius Caesar, The Merchant of Venice, Twelfth Night*

Group II (One to be selected)

Bacon's *Essays;* Irving's *Life of Washington; The Sir Roger de Coverly Papers* in *The Spectator; Franklin's Autobiography*

Group III (One to be selected)

Chaucer's *Prologue;* Spencer's *Faerie Queene* (selections); Pope's *The Rape of the Lock;* Goldsmith's *The Deserted Village;* Palgrave's *Golden Treasury (First Series), Books II and III,* with special attention to Dryden, Collins, Gray, Cowper, and Burns

Group IV (Two to be selected)

Goldsmith's *The Vicar of Wakefield;* Scott's *Ivanhoe;* Scott's *Quentin Durward;* Hawthorne's *The House of the Seven Gables;* Thackeray's *Vanity Fair;* Mrs. Gaskell's *Cranford;* Dickens' *A Tale of Two Cities;* George Eliot's *Silas Marner;* Blackmore's *Lorna Doone*

Group V (Two to be selected)

Irving's *Sketch Book;* Lamb's *Essays of Elia;* De Quincey's *Joan of Arc* and *The English Mail Coach;* Carlyle's *Heroes and Hero Worship;* Emerson's *Essays;* Ruskin's *Sesame and Lilies*

Group VI (Two to be selected)

Coleridge's *The Ancient Mariner;* Scott's *The Lady of the Lake;* Byron's *Mazeppa* and *The Prisoner of Chillon;* Palgrave's *Golden Treasury (First Series), Book IV,* with special attention to Wordsworth, Keats, and Shelley; Macaulay's *Lays of Ancient Rome;* Poe's *Poems;* Lowell's *The Vision of Sir Launfal;* Arnold's *Sohrab and Rustum;* Longfellow's *Evangeline;* Tennyson's *Gareth and Lynette, Lancelot and Elaine,* and *The Passing of Arthur;* Browning's *Cavalier Tunes, The Lost Leader, How They Brought the Good News from Ghent to Aix, Evelyn Hope, Home Thoughts from Abroad, Home Thoughts from the Sea, Incident of the French Camp, The Boy and the Angel, One Word More, Herve Riel, Pheidippides*

II Books prescribed for study and practice

Shakespeare's *Macbeth,* Milton's *Lycidas, Comus, L'Allegro,* and *Il Penseroso;* Burke's *Speech on Conciliation with America,* or Washington's *Farewell Address* and Webster's *First Bunker Hill Oration;* Macaulay's *Life of Johnson,* or Carlyle's *Essay on Burns.*

(c) **Composition** Regular and persistent training in both written and oral composition should be given throughout the

entire school course. The topics should be so chosen as to give practice in the four leading types of prose discourse, namely, description, narration, exposition, and argument.

(d) **Rhetoric** The instruction in this subject should include the following particulars: Choice of words, structure of sentences and paragraphs, the principles of narration, description, exposition, and argument.

The teacher should distinguish between those parts of rhetorical theory which are retained in text books merely through the influence of tradition and those which have a direct bearing upon the composition work. The former may be safely omitted.

HISTORY (2 Units)

Any two of the following periods may be offered:

I Ancient History, with special reference to Greek and Roman History, with a short introductory study of the more ancient nations and the chief events of the early middle ages, down to the death of Charlemagne

II Mediaeval and Modern European History, from the death of Charlemagne to the present time

III English History

IV American History, or American History and Civil Government

MATHEMATICS (3 Units)

The courses offered by the school are so exacting that a thorough training in the following subjects is essential:

I **Essentials of Algebra** (1 Unit) The four fundamental operations for rational algebraic expressions: factoring; complex fractions; the solution of equations of the first degree containing one or more unknown quantities; radicals; theory of indices; quadratic equations and equations containing one or more unknown quantities that can be solved by the methods of quadratic equations; problems dependent on such equations.

II **Advanced Algebra** (½ Unit) This course should begin with a thorough review of the essentials. Later work should cover an introduction to the graphical representation of linear and simple quadratic expressions: ratio and proportion; variation; binomial theorem; the progressions; and logarithms.

III **Plane Geometry** (1 Unit) Completed, with the solution of original exercises and numerical problems.

IV **Solid Geometry** (½ Unit) Properties of straight lines and planes; of dihedral and polyhedral angles; of projection: of polyhedrons, including prisms; of pyramids and the regular solids; of cylinders, cones, and spheres; of spherical triangles, and the mensuration of surfaces and solids.

ADMISSION TO ADVANCED STANDING

Applicants who are graduates of technical or scientific schools or colleges of good standing will be admitted without examination upon the presentation of proper credentials. They will be permitted to take any subject taught in connection with the regular courses, provided, in the opinion of the instructor, their previous experience and training will enable them to pursue the subject with profit. Each case will be judged on its own merits, but applicants will be advised to become candidates for a degree and to complete one of the regular curricula of the school.

Applicants who have partly completed the course in technical or scientific schools or colleges of good standing will be admitted without examination upon the presentation of proper credentials. Due credit will be allowed for the successful completion of work which is equivalent to that given in the Colorado School of Mines. Drawings, laboratory note books, and catalogues of the institution attended, should be submitted with applications for advanced standing. All credits given to advanced standing students are given provisionally, with the understanding that such credits may be withdrawn at any time in case a student fails to maintain a creditable standing. Application blanks will be furnished, by the Registrar, on request.

DEGREES.

The appropriate degree is conferred upon a candidate who fulfils the requirements of the curriculum in which he wishes to obtain his degree:

E. M. Engineer of Mines.
Ch. E. Chemical Engineer.
E. Met. Metallurgical Engineer.
Geol. Eng. Geological Engineer.
P. E. Petroleum Engineer.
M. E. Mechanical Engineer.
E. E. Electrical Engineer.
C. E. Civil Engineer.

Each candidate must fulfil the following conditions:

(a) He must complete all of the work of the freshman and sophomore years.

(b) He must complete all the required work of the curriculum which he elects, and in addition thereto enough elective work to make a total of eighty credit hours.

The presentation of a thesis is optional, but if presented in proper form, from one to five credit hours will be allowed for it. The amount of credit given is at the discretion of the instructor under whom the work is performed.

No diploma will be delivered until the full requirements of the curriculum are satisfied, and all accounts with the school are settled. A minimum residence of one year is required of all candidates for a degree in course.

The degree of M. S. (Master of Science) may be conferred by the Board of Trustees upon a candidate who holds the degree of Engineer of Mines, Metallurgical Engineer or other engineering degree from this school, or the same or equivalent degree from an institution of equal standing, and whose application shall have been approved by the Faculty; provided that the candidate completes the equivalent of forty credit hours, either in regular class or research work, chosen with the approval of the Faculty, and presents an acceptable thesis. One year of residence is also required.

The degree of Sc. D. (Doctor of Science) may be conferred by the Board of Trustees upon a candidate who holds the degree of Master of Science from this school, or the same or equivaent degree from a similar institution of good standing, and whose application shall have been approved by the Faculty; provided that the candidate completes the equivalent of forty credit hours, in regular class and research work, chosen with the approval of the Faculty, and presents an acceptable thesis. Two years of residence are also required.

The degree of Doctor of Philosophy (Ph. D.), or Doctor of Science (Sc. D.), or Doctor of Engineering (Dr. Eng.), may be conferred by the Board of Trustees upon any individual who has been conspicuously successful in advancing the interest of pure or applied science.

DEPARTMENTS OF INSTRUCTION

COURSES OF INSTRUCTION

TABULAR VIEW

FRESHMAN YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
Mathematics I	98	5		Mathematics II	99	5	
Chemistry I	56	4		Chemistry II	56	3	
Chemistry III	56	1		Chemistry IV	57	2	
Chemistry V	57		6	Chemistry VI	57		6
Descriptive Geometry I	77	2		Descriptive Geom. III	77	2	
Descriptive Geometry II	77		6	Descriptive Geom. IV	77		6
English V	86	1		English VI	86	1	
Geology I	89	2		Geology II	89	2	
Military I	120		2	Civil Engineering I	69	1	
Military II	120	1		Military III	120		2
Physical Training	169			Military IV	121	1	
				Physical Training	169		

Civil Engineering II (page 69) (Plane Surveying Field Work) required of all students is given regularly during six weeks of the summer following the close of the freshman year.

Civil Enginering I is given in the first semester, and Civil Enginering II in both semesters, for the benefit of advanced standing students.

TABULAR VIEW

SOPHOMORE YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
Math. V	99	3		Mathematics VI	99	3	
Physics I	130	4		Physics III	130	4	
Physics II	130		6	Physics IV	131		6
Chemistry VII	57	1		Chemistry VIII	58	1	
Chemistry IX	58		6	Chemistry X	58		6
Mech. Engineering V	101	1		Mech. Engineering VII	101	1	
Mech. Engineering VI	101		3	Mech. Engineering VIII	102		3
Geology III	90	2	6	Geology IV	90	2	6
Metal Mining I	115	1		Metal Mining II	115	1	
Military V	121		2	Military VII	121		2
Military VI	121	1		Military VIII	121	1	
Physical Training	169			Physical Training	169		

Metal Mining III (page 115) (Mine Surveying Field Work) required in groups I and IV, is given during the four weeks of the summer following the close of the sophomore year.

Metal Mining IV (page 116) (Mining Laboratory) (Elective) is given for two weeks of the summer following the close of the sophomore year. Credit one hour.

TABULAR VIEW

GROUP I METAL MINING
JUNIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
English I	85	1		English II	85	1	
Mathematics VII	100	2		Geology VII	91	1	6
Metallurgy I	108	1		Mathematics VIII	100	2	
Metallurgy II	108		9	Metallurgy V	109	3	
Metallurgy III	108	3		Metallurgy VI	109	2	
Metallurgy IV	109	2		Metal Mining VII	117	2	
Metal Mining V	116		3	Metal Mining X	117	2	
Metal Mining VI	116	2					
Metal Mining VIII	117	2		**Elective**			
Metal Mining IX	117	1		Chemistry XIII	59	1	
				Chemistry XIV	59		6
				Chemistry XX	60	1	
Elective				Chemistry XXIV	62		3
Chemistry XI	58	1		Chemistry XLI	67		3
Chemistry XII	59		6	Civil Eng. IV	70	2	
Chemistry XXIII	59		3	Civil Eng. XI	74		3
Civil Eng. III	70	2		Civil Eng. XIII	74	2	
Elect. Eng. I	79	2		Des. Geo. V	78		3
Elect. Eng. II	79		3	Elect. Eng. III	80	2	
Elect. Eng. XI	82	1		Elect. Eng. IV	80		3
French I	88	2		Elect. Eng. XII	83	1	
Geology V	90	2		French II	88	2	
Geology VI	91	2		Geology XIV	93		3
Mech. Eng. IX	102	1		Mech. Eng. XI	103	1	
Mechanical Eng. X	102		3	Mech. Eng. XII	103		3
Mech. Eng. XXIV	107	1		Mech. Eng. XX	106	2	
Military IX	122		1	Metallurgy IX	111		3
Military X	122	2		Metal Mining XVI	119	1	
Petroleum Eng. II	126	1		Military XI	122		1
Physics V	131	1		Military XII	122	2	
Physics VII	131		3	Pet. Eng. III	127	2	
Spanish I	133	2		Pet. Eng. IV	127	1	
				Physics VI	131	1	
				Physics VIII	132		3
				Spanish II	132	2	

TABULAR VIEW

GROUP I METAL MINING
Degree—E. M. (Engineer of Mines)
SENIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required			
English III	85	1	
Geology X	92	2	
Metallurgy VII	110	2	
Metallurgy VIII	110		3
Metal Mining XI	118	2	
Metal Mining XIII	118	2	
Elective			
Chemistry XXV	62		3
Chemistry XXVIII	63	2	
Chemistry XXXII	64		3
Chemistry XLII	67		3
Civil Eng. V	71	2	
Des. Geo. VI	78		6
Elect. Eng. V	80	2	
Elect. Eng. IX	81		3
Elect. Eng. XIII	83		3
Elect. Eng. XVIII	84	1	
Geology VIII	91		6
Geology XVI	94		6
Geology XVII	94	1	
Geology XX	95	1	
Hygiene and Camp Sanitation	97	2	
Mech. Eng. XIII	103	2	
Mech. Eng. XIV	104	2	
Mech. Eng. XV	104		6
Mech. Eng. XXIII	106		3
Metallurgy XIV	112	2	
Metallurgy XV	112		3
Metallurgy XVII	113	1	
Military XIII	123		1
Military XIV	123	1	
Military XVII	124		3
Mining Law I	125	1	
Spanish III	132	2	
Thesis			

SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required			
English IV	85	1	
Geology XI	92	2	
Metallurgy X	111	2	
Metallurgy XVIII	113	2	
Metallurgy XIX	113		3
Metal Mining XII	118	2	
Metal Mining XIV	119	2	
Elective			
Chemistry XXVI	63		3
Chemistry XXXVIII	66		3
Civil Eng. XV	75	2	
Civil Eng. XVIII	76	2	
Elect. Eng. VII	81	2	
Elect. Eng. XVII	84	1	
Elect. Eng. XIX	84	1	
Geology IX	92		6
Geology XI	92	2	
Geology XII	92	2	
Geology XV	93	1	
Geology XVIII	95	1	
Geology XXI	95	1	
Mech. Eng. XVII	105	2	
Mech. Eng. XVIII	105		6
Metallurgy XX	113	2	
Metallurgy XXI	114		3
Military XV	123		1
Military XVI	123	1	
Military XVIII	124		3
Pet. Eng. VIII	129	1	
Physics IX	132		3
Spanish IV	134	2	
Thesis			

TABULAR VIEW

GROUP II CHEMICAL ENGINEERING
JUNIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
Chemistry XI	58	1		Chemistry XIII	59	1	
Chemistry XII	59		6	Chemistry XIV	59		6
Chemistry XV	59	2		Chemistry XVII	60	2	
Chemistry XVI	60		3	Chemistry XVIII	60		3
Chemistry XIX	60	2		Chemistry XX	60	1	
English I	85	1		Chemistry XXI	61	2	
Mathematics VII	100	2		Chemistry XXII	61		3
				English II	85	1	
				Mathematics VIII	100	2	
Elective							
Chemistry XXIII	61		3	**Elective**			
Chemistry XL	67		3	Chemistry XXIV	61		3
Civil Eng. III	70	2		Chemistry XLI	67		3
Elect. Eng. I	79	2		Civil Eng. IV	70	2	
Elect. Eng. XI	82	1		Civil Eng. XI	74		3
French I	88	2		Des. Geo. V	78		3
Geology V	90	2		Elect. Eng. III	80	2	
Geology VI	91	2		French II	88	2	
Mech. Eng. XXIV	107	1		Geology VII	91	1	6
Metallurgy I	108	1		Geology XIV	93		3
Metallurgy II	108		9	Mech. Eng. XX	106	2	
Metallurgy III	108	3		Metallurgy I	108	1	
Metallurgy IV	109	2		Metallurgy II	108		9
Metal Mining VI	116	2		Metallurgy V	109	3	
Metal Mining VIII	117	2		Metallurgy VI	109	2	
Metal Mining IX	117	1		Metal Mining VII	117	2	
Military IX	122		1	Metal Mining X	117	2	
Military X	122	2		Military XI	122		1
Pet. Eng. II	126	1		Military XII	122	2	
Physics V	131	1		Physics VI	131	1	
Physics VII	131		3	Physics VIII	132		3
Spanish I	133	2		Spanish II	133	2	

TABULAR VIEW

GROUP II CHEMICAL ENGINEERING

Degree—Ch. Eng. (Chemical Engineer)

SENIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
Chemistry XXVIII	63	2		Chemistry XXIX	63	2	
Chemistry XXXIII	65	1		Chemistry XXXIV	65	1	
Chemistry XXXV	65	1		Chemistry XXXVI	65	1	
English III	85	1		English IV	85	1	
Elective				**Elective**			
Chemistry XXV	62	3		Chemistry XXVI	63		3
Chemistry XXVII	63	1		Chemistry XXXI	64		3
Chemistry XXX	64		3	Chemistry XXXVII	66		3
Chemistry XXXII	64		3	Chemistry XXXVIII	66		3
Chemistry XLII	67		3	Civil Eng. VIII	72		6
Civil Eng. V	71	2		Civil Eng. IX	73		6
Civil Eng. VI	71	2		Civil Eng. XV	75	2	
Civil Eng. XVI	75	1		Civil Eng. XVIII	76	2	
Civil Eng. XVII	75	2		Elect. Eng. VII	81	2	
Des. Geo. VI	78		6	Elect. Eng. VIII	81		6
Elect. Eng. V	80	2		Elect. Eng. X	82		3
Elect. Eng. IX	81		3	Elect. Eng. XIV	83		3
Elect. Eng. XIII	83		3	Elect. Eng. XIX	84	1	
Elect. Eng. XVI	84	2		Geology IX	92		6
Elect. Eng. XVIII	84	1		Geology XI	92	2	
Geology VIII	91		6	Geology XII	92	2	
Geology X	92	2		Geology XV	93	1	
Geology XVI	94		6	Geology XVIII	95	1	
Geology XVII	94	1		Geology XXI	95	1	
Geology XX	95	1		Mech. Eng. XVII	105	2	
Hygiene and Camp Sanitation I	97	2		Mech. Eng. XVIII	105		6
Mech. Eng. XIV	104	2		Mech. Eng. XXII	106	2	
Mech. Eng. XV	104		6	Metallurgy X	111	2	
Mech. Eng. XVI	104	2		Metallurgy XVI	112		3
Metallurgy VII	110	2		Metallurgy XVIII	113	2	
Metallurgy VIII	110		3	Metallurgy XIX	113		3
Metallurgy XIV	112	2		Metallurgy XX	113	2	
Metallurgy XV	112		3	Metallurgy XXI	114		3
Metallurgy XVII	113	1		Metal Mining XII	118	2	
Metal Mining XI	118	2		Metal Mining XIV	119	2	
Metal Mining XIII	118	2		Military XV	123		1
Military XIII	123		1	Military XVI	123	1	
Military XIV	123	1		Pet. Eng. VII	128	3	
Military XVII	124		3	Physics IX	132		3
Mining Law	125	1		Spanish IV	134	2	
Pet. Eng. V	128	3		Thesis			
Spanish III	133	2					
Thesis							

TABULAR VIEW

GROUP III METALLURGY
JUNIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
Chemistry XI	58	1		English II	85	1	
Chemistry XII	59		6	Mathematics VIII	100	2	
English I	85	1		Metallurgy I	108	1	
Mathematics VII	100	2		Metallurgy II	108		9
Metallurgy III	108	3		Metallurgy V	109	3	
Metallurgy IV	109	2		Metallurgy VI	109	2	
Metal Mining VI	116	2		Metallurgy IX	111		3
				Metal Mining VII	117	2	
Elective				**Elective**			
Chemistry XV	59	2		Chemistry XIII	59	1	
Chemistry XVI	60		3	Chemistry XIV	59		6
Chemistry XIX	60	2		Chemistry XVII	60	2	
Chemistry XXIII	61		3	Chemistry XVIII	60		3
Chemistry XL	67		3	Chemistry XX	60	1	
Civil Eng. III	70	2		Chemistry XXI	61	2	
Elect. Eng. XI	82	1		Chemistry XXII	61		3
French I	88	2		Chemistry XXIV	62		3
Geology VI	91	2		Civil Eng. IV	70	2	
Mech. Eng. XXIV	107	1		Elect. Eng. XII	83	1	
Metal Mining V	116		3	French II	88	2	
Metal Mining VIII	117	2		Geology VII	91	1	6
Metal Mining IX	117	1		Mech. Eng. XI	103	1	
Military IX	122		1	Mech. Eng. XII	103		3
Military X	122	2		Mech. Eng. XIX	105	2	
Physics V	131	1		Mech. Eng. XX	106	2	
Physics VII	132		3	Metallurgy XII	111	2	
Spanish I	133	2		Metallurgy XIII	111		3
				Metal Mining X	117	2	
				Metal Mining XVI	119	1	
				Military XI	122		1
				Military XII	122	2	
				Physics VI	131	1	
				Physics VIII	132		3
				Spanish II	133	2	

TABULAR VIEW

GROUP III METALLURGY

Degree—E. Met. (Metallurgical Engineer)

SENIOR YEAR

FIRST SEMESTER	Page	Page Hr.	Lab. Hr.
Required			
English III	85	1	
Metallurgy VII	110	2	
Metallurgy VIII	110		3
Elective			
Chemistry XXVII	63	1	
Chemistry XXVIII	63	2	
Chemistry XXXII	64		3
Chemistry XXXIII	65	1	
Chemistry XXXV	65	1	
Civil Eng. V	71	2	
Civil Eng. VI	71	2	
Civil Eng. XVI	75	3	
Civil Eng. XVII	75	2	
Des. Geo. VI	78		6
Elect. Eng. V	80	2	
Elect. Eng. VI	81		6
Elect. Eng. IX	81		3
Elect. Eng. XIII	83		3
Elect. Eng. XVI	84	2	
Elect. Eng. XVIII	84	1	
Geology VIII	91		6
Geology X	92	2	
Geology XVI	94		6
Geology XX	95	1	
Mech. Eng. XIII	103	2	
Mech. Eng. XIV	104	2	
Mech. Eng. XV	104		6
Mech. Eng. XVI	104	2	
Mech. Eng. XXIII	106		3
Metallurgy XIV	112	2	
Metallurgy XV	112		3
Metallurgy XVII	113	1	
Metal Mining XI	118	2	
Metal Mining XIII	118	2	
Military XIII	123		1
Military XIV	123	1	
Military XVII	124		3
Mining Law I	125	1	
Pet. Eng. VI	128	1	
Spanish III	133	2	
Thesis			

SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required			
English IV	85	1	
Metallurgy X	111	2	
Metallurgy XVIII	113	2	
Metallurgy XIX	113		3
Elective			
Chemistry XXVI	63		3
Chemistry XXIX	63	2	
Chemistry XXXIV	65	1	
Chemistry XXXVI	65	1	
Chemistry XXXVII	66		3
Chemistry XXXIX	67	1	
Civil Eng. IX	73		6
Civil Eng. X	73	2	
Civil Eng. XV	75	2	
Civil Eng. XVIII	76	2	
Elect. Eng. VII	81	2	
Elect. Eng. X	82		3
Elect. Eng. XIV	83		3
Elect. Eng. XVII	84	1	
Elect. Eng. XIX	84	1	
Geology XI	92	2	
Geology XII	92	2	
Geology XV	93	1	
Geology XVIII	95	1	
Geology XXI	95	1	
Mech. Eng. XIII	103	2	
Mech. Eng. XVIII	105		6
Mech. Eng. XXI	106	2	
Metallurgy XVI	112		3
Metallurgy XVII	113	1	
Metallurgy XX	113	2	
Metallurgy XXI	114		3
Metal Mining XII	118	2	
Metal Mining XIV	119	2	
Military XV	123		1
Military XVI	123	1	
Military XVIII	124		3
Pet. Eng. VIII	129	1	
Physics IX	132		3
Spanish IV	134	2	
Thesis			

TABULAR VIEW

GROUP IV GEOLOGICAL ENGINEERING
JUNIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required			
English I	85	1	
Geology V	90	2	
Geology VI	91	2	
Mathematics VII	100	2	
Metallurgy I	108	1	
Metallurgy II	108		9
Metallurgy III	108	3	
Metallurgy IV	109	2	
Metal Mining V	115		3
Elective			
Chemistry XIX	60	2	
Chemistry XXIII	61		3
Civil Eng. III	70	2	
Elect. Eng. XI	82	1	
French I	88	2	
Mech. Eng. IX	102	1	
Mech. Eng. X	102		3
Mech. Eng. XXIV	107	1	
Metal Mining VI	116	2	
Metal Mining VIII	117	2	
Military IX	122		1
Military X	122	2	
Physics V	131	1	
Physics VII	131		3
Spanish I	133	2	

SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required			
English II	85	1	
Geology VII	91	1	6
Geology XIV	93		3
Mathematics VIII	100	2	
Elective			
Chemistry XX	60	1	
Chemistry XXI	61	2	
Chemistry XXII	61		3
Chemistry XXIV	62		3
Chemistry XLI	67		3
Civil Eng. IV	70	2	
Civil Eng. XIII	74	2	
Des. Geo. V	78		3
Elect. Eng. III	80	2	
Elect. Eng. IV	80		3
Elect. Eng. XII	83	1	
French II	88	2	
Mech. Eng. XI	103	1	
Mech. Eng. XII	103		3
Mech. Eng. XX	106	2	
Metallurgy V	109	3	
Metallurgy VI	109	2	
Metallurgy XII	111	2	
Metallurgy XIII	111		3
Metal Mining VII	117	2	
Metal Mining X	117	2	
Metal Mining XVI	119	1	
Military XI	122		1
Military XII	122	2	
Physics VI	131	1	
Physics VIII	132		3
Spanish II	133	2	

Geology XIII (Field Geology) (page 93). Credit three hours. This course is required, and is given for two weeks during the summer following the close of the junior year.

TABULAR VIEW

GROUP IV GEOLOGICAL ENGINEERING
Degree—Geol. Eng. (Geological Engineer)

SENIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required			
English III	85	1	
Geology VIII	91		6
Geology X	92	2	
Geology XVI	94		6
Metal Mining XIII	118	2	
Elective			
Chemistry XXV	62		3
Chemistry XXVII	63	1	
Chemistry XXVIII	63	2	
Chemistry XXXV	65	1	
Chemistry XLII	67		3
Civil Eng. V	71	2	
Civil Eng. VI	71	2	
Civil Eng. XVI	75	3	
Civil Eng. XVII	75	2	
Des. Geo. VI	78		6
Elect. Eng. V	80	2	
Elect. Eng. VI	81		6
Elect. Eng. XIII	83		3
Elect. Eng. XVI	84	2	
Elect. Eng. XVII	84	1	
Elect. Eng. XVIII	84	1	
Geology X	92	2	
Geology XVII	94	1	
Geology XX	95	1	
Hygiene and Camp Sanitation I	97	2	
Mech. Eng. XIII	103	2	
Mech. Eng. XIV	104	2	
Mech. Eng. XVI	104	2	
Mech. Eng. XXIII	106		3
Metallurgy VII	110	2	
Metallurgy VIII	110		3
Metallurgy XVII	113	1	
Metal Mining XI	117	2	
Military XIII	123		1
Military XIV	123	1	
Military XVII	124		3
Mining Law I	125	1	
Pet. Eng. V	128	3	
Pet. Eng. VI	128	1	
Spanish III	133	2	
Thesis			

SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required			
English IV	85	1	
Geology IX	92		6
Geology XI	92	2	
Geology XII	92	2	
Geology XV	93	1	
Elective			
Chemistry XXVI	63		3
Chemistry XXIX	63	2	
Chemistry XXXI	64		3
Chemistry XXXIV	65	1	
Chemistry XXXVI	65	1	
Chemistry XXXVIII	66		3
Chemistry XXXIX	67	1	
Civil Eng. IX	73		6
Civil Eng. X	73	2	
Civil Eng. XV	75	2	
Civil Eng. XVIII	76	2	
Elect. Eng. X	82		3
Elect. Eng. XIV	83		3
Elect. Eng. XIX	84	1	
Geology XVIII	95	1	
Geology XIX	95		
Geology XXI	95	1	
Mech. Eng. XIII	103	2	
Mech. Eng. XVIII	105		6
Mech. Eng. XXI	106	2	
Metallurgy X	111	2	
Metallurgy XVI	112		3
Metallurgy XVIII	113	2	
Metallurgy XIX	113		3
Metal Mining XII	117	2	
Metal Mining XIV	119	2	
Military XV	123		1
Military XVI	123	1	
Military XVIII	124		3
Pet. Eng. VII	128	3	
Physics IX	132		3
Spanish IV	134	2	
Thesis			

TABULAR VIEW

GROUP V PETROLEUM ENGINEERING

JUNIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
Chemistry XIX	60	2		Chemistry XX	60	1	
English I	85	1		Chemistry XXI	61	2	
Geology VI	91	2		Chemistry XXII	61		3
Mathematics VII	100	2		English II	85	1	
Pet. Eng. I	126	2		Mathematics VIII	100	2	
Pet. Eng. II	126	1		Pet. Eng. III	127	2	
				Pet. Eng. IV	127	1	
Elective				**Elective**			
Chemistry XV	59	2		Chemistry XVII	60	2	
Chemistry XVI	60		3	Chemistry XVIII	60		3
Chemistry XXIII	61		3	Chemistry XXIV	62		3
Civil Eng. III	70	3		Civil Eng. IV	70	2	
Elect. Eng. I	79	2		Civil Eng. XI	74		3
Elect. Eng. XI	82	1		Des. Geo. V	78		3
French I	88	2		Elect. Eng. III	80	2	
Geology V	90	2		Elect. Eng. IV	80		3
Mech. Eng. XXIV	107	1		French II	88	2	
Metallurgy I	108	1		Geology VII	91	1	6
Metallurgy II	108		9	Geology XIV	93		3
Metallurgy III	108	3		Mech. Eng. XIX	105	2	
Metallurgy IV	109	2		Mech. Eng. XX	106	2	
Metal Mining VI	116	2		Metallurgy I	108	1	
Metal Mining VIII	117	2		Metallurgy II	108		9
Military IX	122		1	Metallurgy V	109	3	
Military X	122	2		Metallurgy VI	109	2	
Physics V	131	1		Metallurgy IX	111		3
Physics VII	131		3	Metal Mining VII	117	2	
Spanish I	133	2		Metal Mining X	117	2	
				Military XI	122		1
				Military XII	122	2	
				Physics VI	131	1	
				Physics VIII	132		3
				Spanish II	133	2	

TABULAR VIEW

GROUP V PETROLEUM ENGINEERING

Degree—P. E. (Petroleum Engineer)

SENIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
English III	85	1		English IV	85	1	
Pet. Eng. V	128	3		Pet. Eng. VII	128	3	
Pet. Eng. VI	128	1		Pet. Eng. VIII	129	1	
Elective				**Elective**			
Chemistry XXVII	63	1		Chemistry XXIX	63	2	
Chemistry XXXII	64		3	Chemistry XXXIV	65	1	
Chemistry XXXV	65	1		Chemistry XXXVI	65	1	
Civil Eng. V	72	2		Chemistry XXXVIII	66		3
Civil Eng. VI	72	2		Chemistry XXXIX	67	1	
Civil Eng. XVI	75	3		Civil Eng. IX	73		6
Civil Eng. XVII	75	2		Civil Eng. X	73	2	
Elect. Eng. V	80	2		Civil Eng. XV	75	2	
Elect. Eng. VI	81		3	Civil Eng. XVIII	76	2	
Elect. Eng. IX	81		3	Elect. Eng. X	83		3
Elect. Eng. XIII	83		3	Elect. Eng. XIV	83		3
Elect. Eng. XVI	84	2		Elect. Eng. XVII	84	1	
Elect. Eng. XVIII	84	1		Elect. Eng. XIX	84	1	
Geology VIII	91		6	Geology IX	92		6
Geology X	92	2		Geology XII	92	2	
Geology XVI	94		6	Geology XV	93	1	
Geology XVII	94	1		Geology XVIII	95	1	
Geology XX	95	1		Geology XXI	95	1	
Hygiene and Camp				Mech. Eng. XIII	103	2	
Sanitation I	97	2		Mech. Eng. XVIII	105		6
Mech. Eng. XIV	104	2		Mech. Eng. XXI	106	2	
Mech. Eng. XV	104		6	Metallurgy X	111	2	
Mech. Eng. XVI	104		6	Metal Mining XII	118	2	
Mech. Eng. XXIII	106		3	Metal Mining XIV	119	2	
Metallurgy XVII	113	1		Military XV	123	1	
Metal Mining XI	118	2		Military XVI	123	1	
Metal Mining XIII	118	2		Physics IX	132		3
Military XIII	123		1	Spanish IV	134	2	
Military XIV	123	1		Thesis			
Spanish III	133	2					
Thesis							

TABULAR VIEW

GROUP VI MECHANICAL ENGINEERING
JUNIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
Elect. Eng. I	79	2		English II	85	1	
English I	85	1		Mathematics VIII	100	2	
Mathematics VII	100	2		Mech. Eng. XI	103	1	
Mech. Eng. IX	102	1		Mech. Eng. XII	103		3
Mech. Eng. X	102		3	Mech. Eng. XIX	105	2	
Mech. Eng. XXIV	107	1		Mech. Eng. XX	106	2	
Elective				**Elective**			
Chemistry XV	59	2		Chemistry XX	60	1	
Chemistry XVI	60		3	Chemistry XXII	61		3
Chemistry XIX	60	2		Chemistry XXIV	62		3
Chemistry XXIII	61		3	Chemistry XLI	67		3
Chemistry XL	67		3	Civil Eng. IV	70	2	
Civil Eng. III	70	2		Civil Eng. XI	74		3
French I	88	2		Des. Geo. V	78		3
Geology VI	91	2		Elect. Eng. III	80	2	
Metal Mining V	116		3	Elect. Eng. IV	80		3
Metal Mining VI	116	2		Elect. Eng. XII	83	1	
Metal Mining VIII	117	2		French II	88	2	
Metal Mining IX	117	1		Geology VII	91	1	6
Metallurgy I	108	1		Geology XIV	93		3
Metallurgy II	108		9	Metallurgy I	108	1	
Metallurgy III	108	3		Metallurgy II	108		9
Military IX	122		1	Metallurgy V	109	3	
Military X	122	2		Metallurgy VI	109	2	
Pet. Eng. II	126	1		Metallurgy IX	111		3
Physics V	131	1		Metal Mining X	117	2	
Physics VII	131		3	Metal Mining XVI	119	1	
Spanish I	132	2		Military XI	122		1
				Military XII	122	2	
				Pet. Eng. IV	127	1	
				Physics VI	131	1	
				Physics VIII	132		3
				Spanish II	133	2	

TABULAR VIEW

GROUP VI MECHANICAL ENGINEERING

(Proposed)

Degree—M. E. (Mechanical Engineer)

SENIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Page Hr.	Lab. Hr.
Required				**Required**			
Civil Eng. V	71	2		Civil Eng. XVIII	76	2	
English III	85	1		English IV	85	1	
Mech. Eng. XIV	104	2		Mech. Eng. XVIII	105		6
Mech. Eng. XV	104		6	Mech. Eng. XXI	106	2	
Mech. Eng. XVI	104	2					
				Elective			
				Chemistry XXIX	63	2	
Elective				Chemistry XXXI	64		3
Chemistry XXVII	63	1		Chemistry XXXIV	65	1	
Chemistry XXVIII	63	2		Chemistry XXXVI	65	1	
Chemistry XXXIII	65	1		Civil Eng. IX	73		6
Chemistry XXXV	65	1		Civil Eng. X	73	2	
Civil Eng. XVI	75	3		Civil Eng. XV	75	2	
Elect. Eng. IX	81		3	Elect. Eng. X	82		3
Elect. Eng. XIII	83		3	Elect. Eng. XVII	84	1	
Geology VIII	91		6	Elect. Eng. XIX	84	1	
Geology X	92	2		Geology IX	92		6
Geology XVII	94	1		Geology XI	92	2	
Geology XX	95	1		Geology XII	92	2	
Hygiene and Camp				Geology XV	93	1	
Sanitation I	97	2		Geology XVIII	95	1	
Mech. Eng. XIII	103	2		Geology XXI	95	1	
Mech. Eng. XXIII	106		3	Mech. Eng. XXII	106	2	
Metallurgy VII	110	2		Metallurgy X	111	2	
Metallurgy VIII	110		3	Metallurgy XVIII	113	2	
Metallurgy XIV	112	2		Metallurgy XIX	113		3
Metallurgy XV	112		3	Metallurgy XX	113	2	
Metallurgy XVII	113	1		Metallurgy XXI	114		3
Metal Mining XI	118	2		Metal Mining XII	118	2	
Metal Mining XIII	118	2		Metal Mining XIV	119	2	
Military XIII	123		1	Military XV	123		1
Military XIV	123	1		Military XVI	123	1	
Mining Law I	125	1		Physics IX	132		3
Spanish III	133	2		Spanish IV	134	2	
Thesis				Thesis			

TABULAR VIEW

GROUP VII ELECTRICAL ENGINEERING
JUNIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
Elect. Eng. I	79	2		Elect. Eng. III	80	2	
Elect. Eng. II	79		3	Elect. Eng. IV	80		3
Elect. Eng. XI	82	1		Elect. Eng. XII	83	1	
English I	85	1		English II	85	1	
Mathematics VII	100	2		Mathematics VIII	100	2	
Elective				**Elective**			
Chemistry XV	59	2		Chemistry XVII	60	1	
Chemistry XIX	60	2		Chemistry XXI	61	2	
Chemistry XXIII	61		3	Chemistry XXII	61		3
Chemistry XL	67		3	Chemistry XXIV	62		3
Civil Eng. III	70	2		Chemistry XLI	67		3
French I	88	2		Civil Eng. IV	70	2	
Geology VI	91	2		Civil Eng. XI	74		3
Metallurgy I	108	1		Des. Geo. V	78		3
Metallurgy II	108		9	Elect. Eng. XV	83	1	
Metallurgy III	108	3		French II	88	2	
Metallurgy IV	109	2		Geology VII	91	1	6
Metal Mining VI	116	2		Geology XIV	93		3
Metal Mining VIII	117	2		Mech. Eng. XIX	105	2	
Metal Mining IX	117	1		Mech. Eng. XX	106	2	
Military IX	122		1	Metallurgy I	108	1	
Military X	122	2		Metallurgy II	108		9
Pet. Eng. I	126	2		Metallurgy V	109	3	
Pet. Eng. II	126	1		Metallurgy VI	109	2	
Physics V	131	1		Metallurgy IX	110		3
Physics VII	131		3	Metal Mining VII	117	2	
Spanish I	132	2		Metal Mining X	117	2	
				Metal Mining XVI	119	1	
				Military XI	122		1
				Military XII	122	2	
				Physics VI	131	1	
				Physics VIII	132		3
				Spanish II	132	2	

TABULAR VIEW

GROUP VII ELECTRICAL ENGINEERING
(Proposed)

Degree—E. E. (Electrical Engineer)

SENIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
Elect. Eng. IX	81		3	Elect. Eng. X	82		3
Elect. Eng. XIII	83		3	Elect. Eng. XIV	83		3
Elect. Eng. XVI	84	2		Elect. Eng. XVII	84	1	
Elect. Eng. XVIII	84	1		Elect. Eng. XIX	84	1	
English III	85	1		English IV	85	1	
				Mech. Eng. XVIII	105		6
Elective							
Chemistry XXV	62		3	**Elective**			
Chemistry XXVII	63	1		Chemistry XXVI	63	3	
Chemistry XXVIII	63	2		Chemistry XXIX	63	2	
Chemistry XXXII	64		3	Chemistry XXXI	64		3
Chemistry XXXIII	65	1		Chemistry XXXIV	65	1	
Chemistry XXXV	65	1		Chemistry XXXVI	65	1	
Civil Eng. V	71	2		Chemistry XXXVIII ...	66		3
Civil Eng. XVI	75	3		Civil Eng. X	73	2	
Des. Geo. VI	78		6	Civil Eng. XV	75	2	
Elect. Eng. V	80	2		Civil Eng. XVIII	76	2	
Elect. Eng. VI	81		6	Elect. Eng. VII	81	2	
Geology VIII	91		6	Elect. Eng. VIII	81		6
Geology X	92	2		Geology IX	92		6
Geology XVI	94		6	Geology XI	92	2	
Geology XVII	94	1		Geology XXI	95	1	
Geology XX	95	1		Mech. Eng. XIII	103	2	
Hygiene and Camp				Mech. Eng. XVII	105	2	
Sanitation I	97	2		Mech. Eng. XXI	106	2	
Mech. Eng. XIII	103	2		Metallurgy X	111	2	
Mech. Eng. XIV	104	2		Metallurgy XVIII	113	2	
Mech. Eng. XV	104		6	Metallurgy XIX	113		3
Metallurgy XIV	112	2		Metallurgy XX	113	2	
Metallurgy XV	112		3	Metallurgy XXI	114		3
Metallurgy XVII	113	1		Military XV	123		1
Metal Mining XI	118	2		Military XVI	123	1	
Military XIII	123		1	Military XVIII	124		3
Military XIV	123	1		Pet. Eng. VII	128	3	
Military XVII	124		3	Pet. Eng. VIII	129	1	
Mining Law I	125	1		Physics IX	132		3
Pet. Eng. V	128	3		Spanish IV	134	2	
Pet. Eng. VI	128	1		Thesis			
Spanish III	133	2					
Thesis							

TABULAR VIEW

GROUP VIII CIVIL ENGINEERING
JUNIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lect. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
Civil Eng. III	70	2		Civil Eng. IV	70	2	
Civil Eng. V	71	2		Civil Eng. XI	74		3
Civil Eng. VII	72		6	Civil Eng. XIII	74	2	
Civil Eng. XII	74		6	English II	85	1	
English I	85	1		Mathematics VIII	100	2	
Mathematics VII	100	2		Metal Mining XVI	119	1	
Elective				**Elective**			
Chemistry XV	59	2		Chemistry XVII	60	2	
Chemistry XVI	60		3	Chemistry XVIII	60		3
Chemistry XIX	60	2		Chemistry XX	60	1	
Chemistry XXIII	61		3	Chemistry XXI	61	2	
Chemistry XL	67		3	Chemistry XXIV	62		3
Elect. Eng. XI	82	1		Des. Geo. V	78		3
French I	88	2		Elect. Eng. III	80	3	
Geology V	90	2		Elect. Eng. XII	83	1	
Geology VI	91	2		French II	88	2	
Mech. Eng. XXIV	107	1		Geology VII	91	1	6
Metallurgy III	108	3		Mech. Eng. XIX	105	2	
Metallurgy IV	109	2		Mech. Eng. XX	106	2	
Metal Mining V	116		3	Metallurgy V	109	3	
Metal Mining VI	116	2		Metallurgy VI	109	2	
Metal Mining VIII	117	2		Metallurgy IX	111		3
Metal Mining IX	117	1		Metal Mining VII	117	2	
Military IX	122		1	Metal Mining X	117	2	
Military X	122	2		Military XI	122		1
Pet. Eng. II	126	1		Military XII	122	2	
Physics V	131	1		Physics VI	131	1	
Physics VII	131		3	Physics VIII	132		3
Spanish I	133	2		Spanish II	133	2	

TABULAR VIEW

GROUP VIII CIVIL ENGINEERING
(Proposed)
Degree—C. E. (Civil Engineer)
SENIOR YEAR

FIRST SEMESTER	Page	Lect. Hr.	Lab. Hr.	SECOND SEMESTER	Page	Lect. Hr.	Lab. Hr.
Required				**Required**			
Civil Eng. V	71	2		Civil Eng. X	73	2	
Civil Eng. VI	71	2		Civil Eng. XV	75	2	
Civil Eng. XIV	74	2		Civil Eng. XVIII	76	2	
Civil Eng. XVI	75	3		English IV	85	1	
Civil Eng. XVII	75	2					
English III	85	1					
				Elective			
				Chemistry XXIX	63	2	
Elective				Chemistry XXXI	64		3
Chemistry XXV	62		3	Chemistry XXXVIII	66		3
Chemistry XXVIII	63	2		Chemistry XXXIX	67	1	
Chemistry XXXII	64		3	Civil Eng. VIII	72		6
Des. Geo. VI	78		6	Civil Eng. IX	73		6
Elect. Eng. IX	81		3	Elect. Eng. X	82		3
Elect. Eng. XIII	83		3	Elect. Eng. XIV	83		3
Geology VIII	91		6	Elect. Eng. XVII	84	1	
Geology XVII	94	1		Elect. Eng. XIX	84	1	
Geology XX	95	1		Geology IX	92		6
Hygiene and Camp				Geology XI	92	2	
Sanitation I	97	2		Geology XII	92	2	
Mech. Eng. XIII	103	2		Geology XV	93	1	
Mech. Eng. XXIII	106		3	Geology XXI	95	1	
Metallurgy XIV	112	2		Mech. Eng. XIII	103	2	
Metallurgy XV	112		3	Mech. Eng. XVIII	105		6
Metallurgy XVII	113	1		Metallurgy X	111	2	
Metal Mining XIII	118	2		Metallurgy XVIII	113	2	
Military XIII	123		1	Metallurgy XIX	113		3
Military XIV	123	1		Metallurgy XX	113	2	
Military XVII	124		3	Metallurgy XXI	114		3
Mining Law I	125	1		Metal Mining XII	118	2	
Spanish III	133	2		Metal Mining XIV	119	2	
Thesis				Military XV	123		1
				Military XVI	123	1	
				Pet. Eng. VII	128	3	
				Pet. Eng. VIII	129	1	
				Physics IX	132		3
				Spanish IV	134	2	
				Thesis			

CHEMISTRY

Albert H. Low, Professor.
Lewis Dillon Roberts, Associate Professor.
Wilfred Welday Scott, Associate Professor.
Will Victor Norris, Assistant Professor.
Arthur J. Franks, Instructor.
Thomas G. Foulkes, Fellow.
A. C. Lansing, Fellow.
J. B. Mull, Fellow.

The courses in Chemistry are arranged to cover the needs of the mining, metallurgical, petroleum, and chemical engineer. These different branches, as the case may be, require a thorough understanding of the laws and theories of organic and inorganic chemistry, and the ability to apply this knowledge to analytical and industrial problems.

I GENERAL CHEMISTRY **Lectures**

In this course and Course II the fundamental principles of chemistry are considered. The non-metallic elements are studied, and, in order to help the student in qualitative analysis, some of the common metallic elements are included in this course.

Prerequisite: Entrance requirements.

Three hours a week during the first semester of the freshman year.

Required of all students. (Roberts)

II GENERAL CHEMISTRY **Lectures**

This course is a continuation of Course I, and concludes the study of the metallic elements and their compounds. The object of Courses I and II is to furnish as complete a foundation in all the fundamental principles of chemistry as is possible to acquire within the time. The production and uses of the most important industrial products are considered.

Prerequisite: Course I.

Three hours a week during the second semester of the freshman year.

Required of all students. (Roberts)

III GENERAL CHEMISTRY MANIPULATIONS **Lectures**

The object of this course is to teach the necessary manipulation involved in the preparation of elements and compounds, and in such other work as is carried out in the general chemistry

laboratory. This is to familiarize the student with the correct handling of apparatus and the precautions necessary in experimental work.

Prerequisite: Entrance requirements.

Two hours a week during the first semester of the freshman year.

Required of all students. (Norris)

IV QUALITATIVE ANALYSIS Lectures

In this course the principles of qualitative analysis are emphasized. Consideration is given to the relative solubility of substances, oxidation and reduction reactions, and the reactions involved in the systematic analysis of inorganic substances. The aim is to teach rapid, accurate analytical methods, in conjunction with the underlying principles, to serve as proper preparation for laboratory work.

Prerequisites: Courses I, III and V.

One hour a week during the second semester of the freshman year.

Required of all students. (Norris)

V GENERAL CHEMISTRY Laboratory

Each student is given detailed instruction in the methods employed in the preparation of inorganic substances, in order that the technical student may have a suitable basis for future work. The laboratory work corresponds with the instruction given in the lectures.

Prerequisite: Entrance requirements.

Six hours a week during the first semester of the freshman year.

Required of all students. (Norris)

VI QUALITATIVE ANALYSIS Laboratory

This course includes the separation and detection of the cations and anions involved in the analysis of solutions and dry substances. The detections necessary in the analysis of ores, slags, alloys, and other industrial and commercial products, are taken up in detail.

Prerequisites: Courses I, III and V

Six hours a week during the second semester of the freshman year.

Required of all students. (Norris)

VII QUANTITATIVE ANALYSIS Lectures

This course includes a study of the theory, apparatus, and manipulations employed in gravimetric analysis. Emphasis is placed on the operations, reactions, and calculations necessary in the methods used in Course IX.

Prerequisites: Courses I to VI, inclusive

One hour a week during the first semester of the sophomore year.

Required of all students. (Scott)

VIII QUANTITATIVE ANALYSIS **Lectures**

This course takes up the study of volumetric analysis and includes, acidimetric, alkalimetric, oxidation and reduction methods. Emphasis is placed upon the accuracy, care and integrity required in quantitative analysis, with an endeavor to promote thoughtful and intelligent work.

Prerequisites: Courses VII and IX.

One hour a week during the second semester of the sophomore year.

Required of all students. (Scott)

IX QUANTITATIVE ANALYSIS **Laboratory**

This course is devoted to the gravimetric analysis of simple compounds, including sulphur, barium, aluminum, magnesium, calcium, the analysis of limestone for the commonly occurring constituents, and the proximate analysis of coal.

Prerequisite: Registration in Course VII.

Six hours a week during the first semester of the sophomore year.

Required of all students. (Scott, Franks)

X QUANTITATIVE ANALYSIS **Laboratory**

This course consists of laboratory practice of methods outlined in Course VIII, and includes the volumetric determination of acids, alkali hydroxides and carbonates, calcium, iron, manganese, lead, copper, arsenic and antimony in ores, concentrates, tailings or slags, using methods employed by the best commercial and smelter laboratories. Emphasis is placed on accuracy and speed, not only in the analysis of the unknown substance, but also in the preparation of the standard solutions and in the calculations.

Prerequisite: Registration in Course VIII.

Six hours a week during the second semester of the sophomore year.

Required of all students. (Scott, Franks)

XI ADVANCED QUANTITATIVE ANALYSIS **Lectures**

This work is an extension of the quantitative analysis of the sophomore year, and takes up the study of methods for the determination of silver, nickel, cobalt, mercury, tin, chromium, molybdenum, tungsten, uranium and vanadium in alloys and in minerals.

Prerequisites: Courses VIII and X.

One hour a week during the first semester of the junior year.

Required in Groups II and III. (Scott)

XII ADVANCED QUANTITATIVE ANALYSIS **Laboratory**

Credit two hours.

Laboratory practice in the methods studied in Course XI.

Prerequisite: Registration in Course XI

Six hours a week during the first semester of the junior year.

Required in Groups II and III. (Scott, Franks)

XIII METALLURGICAL ANALYSIS **Lectures**

Credit one hour.

This course is intended to familiarize the student with the analytical methods used in the metallurgical industries. A study is made of the technical methods used in the analysis of slags, mattes, flue dust, iron, steel, spelter, metallic copper, refined lead, bearing metals, and other alloys.

Prerequisites: Courses VIII and X.

One hour a week during the second semester of the junior year.

Required in Group II. (Scott)

XIV METALLURGICAL ANALYSIS **Laboratory**

Credit two hours.

Laboratory practice selected from the methods studied in Course XIII.

Prerequisite: Registration in Course XIII

Six hours a week during the second semester of the junior year.

Required in Group II. (Scott, Franks)

XV PHYSICAL CHEMISTRY **Lectures**

Credit two hours.

A study of the laws and theories underlying chemical phenomena from the standpoint of their application to the problems of the chemist and the metallurgist. Some of the subjects considered are: theories of atomic structure and properties; the periodic law; solutions; electrolytes; colloids; chemical equilibrium; velocity of chemical action; catalysis and thermo-chemistry.

Prerequisites: Courses VIII and X, Math. VI, Physics III and IV

Two hours a week during the first semester of the junior year.

Required in Group II (Roberts)

XVI PHYSICAL CHEMISTRY **Laboratory**

Credit one hour.

Laboratory experiments to accompany Course XV.

Prerequisites: Registration in Course XV

Three hours a week during the first semester of the junior year.

Required in Group II (Roberts)

XVII PHYSICAL CHEMISTRY **Lectures**

Credit two hours.

The object of this course is to study the phenomena in physical chemistry most important to the engineer. Some of the subjects discussed are chemical equilibrium, velocity of chemical action, catalysis, colloids, thermo-chemistry, surface tension, viscosity, and electrolysis.

Prerequisites: Courses XV and XVI.

Two hours a week during the second semester of the junior year.

Required in Group II (Roberts)

XVIII PHYSICAL CHEMISTRY **Laboratory**

Credit one hour.

Laboratory experiments to accompany Course XVII

Prerequisites: Registration in Course XVII

Three hours a week during the second semester of the junior year.

Required in Group II (Roberts)

XIX ORGANIC CHEMISTRY **Lectures**

Credit two hours.

The purpose of this course is to present the fundamentals of general organic chemistry and to give the student a broad outlook on its application to the industries, especially those of petroleum and oil shale. Emphasis is laid upon type reactions, the relationships that exist between the various compounds, and the theoretical considerations underlying the whole.

Prerequisites: This course is intended primarily for regular students of the junior class, but others may take it with the consent of the instructor.

Two hours a week during the first semester of the junior year.

Required in Groups II and V. (Franks)

XX PETROLEUM AND SHALE OIL ANALYSIS **Lectures**

Credit one hour.

In this course the different classes of petroleums and shale oils, and the products therefrom, are reviewed. Methods of

analysis and evaluation are studied critically. The use of standard apparatus is explained. The physics and chemistry underlying each analysis or test are discussed in detail. Emphasis is laid upon the value and significance of the various tests in their relation to commercial specifications.

Prerequisites: Course XIX.

One hour a week during the second semester of the junior year.

Required in Groups II and V. (Franks)

XXI THE PRINCIPLES OF PETROLEUM AND SHALE OIL REFINING Lectures

Credit two hours.

The fundamental principles involved in petroleum and shale oil refining are given detailed consideration. The physics and chemistry of each process are studied in connection with demonstrations given during the lectures. The coordination between theory and commercial practice is pointed out.

Prerequisite: Course XIX.

Two hours a week during the second semester of the junior year.

Required in Groups II and V. (Franks)

XXII PETROLEUM AND SHALE OIL ANALYSIS Laboratory

Credit one hour.

This is the laboratory course accompanying Course XX. Its purpose is to familiarize the student with the standard methods of analysis and the apparatus used. The best technique to promote rapidity and accuracy is emphasized throughout.

Prerequisites: Course XIX and registration in Course XX

Three hours a week during the second semester of the junior year.

Required in Groups II and V. (Franks)

XXIII TECHNICAL ORE ANALYSIS Lectures and Laboratory (Elective)

Credit one hour.

In this course the fundamental principles of quantitative analysis are given practical application in the determination of the more commonly required constituents, from a metallurgical standpoint, of complex ores. The preparation of samples, method of weighing, and other necessary details are carefully considered, together with the preparation of the necessary standard solutions for volumetric work. The most rapid and approved methods of analysis are explained and demonstrated, in order to adapt the student thoroughly to the requirements of actual practice. Cor-

rect manipulation and systematic methods of work are insisted upon, to acquire speed and accuracy. A special endeavor is made throughout these technical courses to teach the student to observe carefully, to think logically for himself, and to manipulate correctly.

Prerequisite: This course is intended primarily for regular members of the junior class, but others may take it with the consent of the instructor.

Three hours a week during the first semester of the junior year. (Low)

XXIV TECHNICAL ORE ANALYSIS **Lectures and Laboratory** (Elective)

Credit one hour.

This course is a continuation of Course XXIII and includes the determination, in smelter samples, of important constituents of ores and metallurgical products, requiring, as a rule, more time and technical skill than is necessary in the work of Course XXI. Different methods of analysis are compared, in order that the proper choice may be made in specific cases. Special attention is paid to the recognition of the essential points of such chemical reactions as are encountered, so as to apply them quickly in practical work.

Prerequisite: This course is intended primarily for regular members of the junior class, but others may take it with the consent of the instructor.

Three hours a week during the second semester of the junior year. (Low)

XXV TECHNICAL ORE ANALYSIS **Lectures and Laboratory** (Elective)

Credit one hour.

Students in this course are instructed in the latest technical methods for the determination of the rarer constituents of ores that have attained commercial importance. Also, the very important, but more unusual, determinations that are liable to be required in practical work. Special attention is paid to the selection of the best method for particular cases, and accuracy, rather than speed, is emphasized.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor.

Three hours a week during the first semester of the senior year. (Low)

XXVI TECHNICAL ORE ANALYSIS **Lectures and Laboratory** (Elective)

Credit one hour.

Important analytical work of a diversified nature is taken up in this course. Boiler water, heating value of fuels, analysis of flue gases, examination of salts and brines, nitrates in ores and salts, phosphate rock, graphite in ores and similar work of practical value to the mining engineer or metallurgist.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor.

Three hours a week during the second semester of the senior year. (Low)

XXVII RADIOACTIVITY **Lectures** (Elective)

Credit one hour.

The objects of the course are to acquaint the student with the radioactive series in general, to study how practical determinations and measurements are made, and to consider the physical and chemical relations of the disintegration products.

Prerequisites: Course XV and Physics III and IV

One hour a week during the first semester of the senior year. (Roberts)

XXVIII GENERAL ORGANIC CHEMISTRY **Lectures**

Credit two hours.

A course covering the general principles and theories of organic chemistry. Characteristic reactions and methods of preparation of organic compounds are illustrated with special attention paid to those of a theoretical or commercial importance.

Prerequisite: This course is intended primarily for regular students of the junior class, but others may take it with the consent of the instructor.

Two hours a week during the first semester of the senior year.

Required in Group II. (Low)

XXIX GENERAL ORGANIC CHEMISTRY **Lectures**

Credit two hours.

A continuation of Course XXVIII. More advanced topics are taken up and the application of the theories and the observed facts to actual practice are noted and emphasized.

Prerequisite: Course XXVIII

Two hours a week during the second semester of the senior year.

Required in Group II. (Low)

XXX GENERAL ORGANIC CHEMISTRY **Laboratory** (Eective)

Credit one hour.

This course is to familiarize the student with organic laboratory work. The apparatus involved and the operations necessary are studied in connection with the work in hand. The latter includes fractional distillation, steam distillation, crystallization, extraction, the determination of melting and boiling points and other work of a fundamental nature. Characteristic reactions of organic compounds are tested by experiment and their relations to organic analytical work emphasized. General and specific methods of preparation of organic compounds are carried out in connection with the study of the theories involved. Qualitative tests are made for all the important constituents of organic compounds.

Prerequisite: Registration in Course XXVIII

Three hours a week during the first semester of the senior year. (Low)

XXXI GENERAL ORGANIC CHEMISTRY **Laboratory** (Elective)

Credit one hour.

This course includes the preparation of various organic compounds, specially emphasizing reactions and preparations of commercial importance. Quantitative determinations are made of carbon, hydrogen, nitrogen, and the halogens. Synthetic work is carried out and opportunity for research afforded.

Prerequisite: Registration in Course XXIX

Three hours a week during the second semester of the senior year.

(Low)

XXXII GAS ANALYSIS **Lectures and Laboratory** (Elective)

Credit one hour.

This course is to familiarize the student with the quantitative analysis of gases commonly examined in the technical laboratory. It includes the determination of carbon dioxide, carbon monoxide, oxygen, hydrogen, illuminants, sulphur dioxide, sulphuric acid mist, chlorides in suspension, traces of dust and moisture in gases.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor.

Three hours a week during the first semester of the senior year. (Scott)

XXXIII CHEMICAL ENGINEERING **Lectures and Conferences**
Credit one hour.

In this course the methods employed in the industrial application of such processes as evaporation, distillation, lixiviation, sedimentation, crystallization and electrolysis are taken up and studied, so as to familiarize the student with the means by which desired results may be attained.

Prerequisite: This course is intended primarily for regular students of the senior class, but others may take it with the consent of the instructor.

One hour a week during the first semester of the senior year.

Required in Group II. (Low)

XXXIV CHEMICAL ENGINEERING **Lectures and Conferences**
Credit one hour.

The methods and operations previously studied are considered with reference to their application to typical commercial processes. The qualitative and quantitative necessities are indicated and the situations presented are considered in detail with reference to final desired results. Practical quantitative determinations relative to the operations and the methods involved in a commercial process are especially emphasized.

Prerequisite: Course XXXIII

One hour a week during the second semester of the senior year.

Required in Group II. (Low)

XXXV INDUSTRIAL CHEMISTRY **Lectures**
Credit one hour.

In this course the more important industrial chemical processes are studied. The fundamental principles underlying the chemical and physical operations involved are considered in connection with the various forms of apparatus in industrial use.

Prerequisite: This course is intended primarily for the regular students of the senior class, but others may take it with the consent of the instructor.

One hour a week during the first semester of the senior year.

Required in Group II. (Scott)

XXXVI INDUSTRIAL CHEMISTRY **Lectures**
Credit one hour.

This is a continuation of Course XXXV. There is a further study of methods and apparatus both in general and as employed in specific cases. Raw material, standard types and sizes of apparatus, sources and cost of energy and correlated subjects

are considered in connection with various processes and the plants necessary for their operation.

Prerequisite: This course is intended primarily for regular students of the senior class, but others may take it with the consent of the instructor.

One hour a week during the second semester of the senior year.

Required in Group II. (Scott)

XXXVII INDUSTRIAL CHEMISTRY Laboratory (Elective)

Credit one hour.

In this course the student becomes familiar with the actual use of various forms of apparatus previously studied. The employment of the apparatus is taken in connection with the preparation of such industrial products as are possible and advisable on a laboratory scale. The student is encouraged to devise special processes for old or new industrial preparations, carrying out the experimental work on as large a scale as practicable or necessary and in such a way as to permit of elaboration into a commercial process. In all experimental work complete analytical check is made and all necessary physical tests are carried out on the main and by-products, in order to obtain the required quantitative data. The various factors of plant construction and operation are given due consideration and study.

Prerequisite: Registration in Course XXXVI.

Three hours a week during the second semester of the senior year. (Scott)

XXXVIII ADVANCED INORGANIC CHEMISTRY Laboratory (Elective)

Credit one hour.

In this course opportunity is given to apply the chemical knowledge previously acquired, to the study of commercially important questions of an inorganic nature. Problems relative to the detection and quantitative estimation of objectionable impurities in raw materials and finished products are investigated with special reference to improvement. Consideration is also given to the extraction or separation from raw materials or compounds of elements of commercial importance. The work undertaken may vary with the student, and the subjects include the preparation and purification of salts, determination of solubilities, study and uses of indicators, investigation of analytical methods, electrolysis, properties of rare elements and other matters of an inorganic nature as suggested.

Prerequisite: This course is intended primarly for regular members of the senior class, but others may take it with the consent of the instructor.

Three hours a week during the second semester of the senior year. (Low)

XXXIX SPECIAL MEMOIRS AND THESIS REPORTS (Elective)

Credit one hour.

This course is devoted to the consideration and discussion of reports relative to special investigations assigned or to thesis work. Statements are given as to progress made and criticisms or suggestions from the instructor or others are discussed, with the object of facilitating the work and imparting knowledge gained for mutual benefit.

Prerequisite: This course is intended primarily for regular members of the senior class, but others may take it with the consent of the instructor.

One hour a week during the second semester of the senior year. (Low)

XL ELECTROCHEMISTRY **Lectures and Laboratory** (Elective)

Credit one hour.

Electrochemical reactions are considered. Technical applications are studied and illustrated in the laboratory.

Prerequisite: Course XVII.

Three hours a week during the first semester of the junior year. (Roberts)

XLI CHEMICAL SPECTROSCOPY **Laboratory** (Elective)

Credit one hour.

The student is made familiar with the use of the spectroscope, colorimeter, polariscope, and refractometer, as applied to chemical problems. A study is made of the arc, spark, and absorption spectra and the application of spectroscopic methods to analysis.

Prerequisite: Course XVII.

Three hours a week during the second semester of the junior year. (Roberts)

XLII ELECTROMETRIC TITRATIONS **Laboratory** (Elective)

Credit one hour.

The electrometric method of titration of the hydrogen ion is fully demonstrated and explained, and the application of the method to the titration of opaque mixtures is carried out and studied by the student in the laboratory.

Prerequisite: Course XVII.

Three hours a week during the first semester of the senior year. (Roberts)

CIVIL ENGINEERING

Harold Ward Gardner, Professor
Fred L. Serviss, Fellow.

The courses in civil engineering are arranged to give the student a thorough training in the fundamentals of the problems with which the civil engineer is likely to be confronted. The solution of these problems always requires a knowledge of the properties of materials. Consequently, considerable time is devoted to studying the principles of mechanics of materials and structures and the effect of actions upon them.

I THEORY OF PLANE SURVEYING Lectures

In this course the student is first made familiar with the various kinds of surveying instruments and their uses. Careful instruction in the elementary principles of surveying supplemented with numerous examples, is designed to make the student acquire accuracy in the calculations of the various kinds of problems likely to be met with in this work. The course is systematically arranged, taking up first general methods of measurement by means of the steel tape or chain, comparison to a standard unit at a given temperature, followed by examples in the making and reduction of transit and level notes, together with a brief study of stadia and plane table methods. City, land, and railroad surveying are taken up in turn, together with parting of land, traverses, and the more simple cases of triangulation. The student is especially impressed with the importance of keeping clear and concise notes.

Prerequisite: Math. I

One hour a week during the second semester of the freshman year.

Required of all students. (Gardner)

(This course is also given in the first semester for irregular and advanced standing students.)

II PRACTICE OF PLANE SURVEYING Lectures and Field Work

The field work in plane surveying is conducted in the vicinity of Golden. Practical applications of the principles studied in the preceding course are here carried out in detail. The student is required to be able to measure distances accurately over rough ground with the steel tape and to handle the transit and level correctly. Each squad, consisting of two men, is required to

perform several field exercises, including adjusting instruments; setting grade stakes; staking out horizontal and vertical curves, borrow pits, frogs, and switches, and three-level sections; making topographic maps with plane table and transit and stadia; measuring a base line and angles; and computing the lengths of the sides of a triangulation system. They are required, also, to make azimuth, time and latitude determinations from observations on the sun and Polaris. An effort is made to impress on the students the necessity of being neat and accurate, and of applying a check on all work.

Prerequisite: Course I

Six weeks in the summer following the close of the freshman year.

Required of all students. (Gardner)

(This course is also given during the school year for irregular and advanced standing students.)

III MECHANICS OF MATERIALS

Credit two hours.

This course consists of a general study of the strength of engineering materials and the theory of elasticity. It begins with the more simple phenomena of compression, tension, and shear, and continues through those of torsion and flexure. It is intended to give the student a comprehensive understanding of the elementary conceptions of stresses and to enable him to interpret stress-strain diagrams. Considerable importance is attached to graphical representation of ideas and to the solution of problems, part of which are taken from the text and part from other sources. Frequent references are made to the specifications of the American Society for Testing Materials and other organizations. The subjects considered in the course include stresses and deformations in shafts and simple and cantilever beams, the design of riveted joints, horizontal shear in beams, shear and moment diagrams for simple and cantilever beams, and the derivation of the formulas for their elastic curves.

Prerequisites: Mathematics V and VI, and registration in Math. VII.

Two hours a week during the first semester of the junior year.

Required in Group VIII. (Gardner)

IV MECHANICS OF MATERIALS

Credit two hours.

This course is an advanced course in strength of materials. It is a continuation of Course III and involves a study of the more complicated stresses in structural members. The subjects

considered include beams on more than two supports, the theorem of three moments, combined shear and flexure stresses in beams, beams of special form, the derivation and comparison of column formulas including the secant formula and their application in practice, resilience, moment and product of inertia, work and energy, fatigue, and reinforced concrete.

Prerequisite: Course III

Two hours a week during the second semester of the junior year.

Required in Group VIII. (Gardner)

V HYDRAULICS **Lectures**

Credit two hours.

This course is begun with a brief treatment of hydrostatics, after which are considered the properties of fluids in motion, the flow of liquids through pipes and orifices and over weirs, fluid friction, and consequent losses of head. Special emphasis is placed on Bernouilli's Theorem of conservation of energy as the basis for the solution of all problems relating to the flow of water in pipes and channels. The student is made familiar with empirical formulas which have been deduced through experiments by recognized authorities on hydraulics. Numerous problems involving the flow of water through pipes are solved. A brief study of water wheels, both of the impulse and turbine type, is made and the underlying principles of design are noted. Some of the factors entering into the development of water power are taken up as time permits, such as stream measurements, mass diagrams for computing storage requirements, certain general items of construction, and choice of units to suit load conditions.

Prerequisite: Course III.

Two hours a week during the first semester of the senior year.

Required in Group VIII. (Gardner)

VI ROADS AND PAVEMENTS

Credit two hours.

The course is conducted largely as a seminar in which each student is required to present a discussion on at least two subjects relating to some phase of road work. Considerable latitude is permitted in choice of subjects as a means of broadening the scope of the course. In addition to the discussions, assignments are made regularly of reading matter in the text and of problems. The list of problems includes those relating to rainfall and runoff, drainage, draft on various kinds of roads, design and estimates for culverts, proportioning ingredients for artificial

paving materials, and so forth. Subjects discussed include financing, construction and maintaining road improvements; source, manufacture and production of paving material; cost analysis; biographical sketches of Whistler, Rennie, Mac Adam, Telford, Smeaton, Stevenson, Apsden, Vicat, and other early engineers.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor.

Two hours a week during the first semester of the senior year.

Required in Group VIII. (Gardner)

VII GRAPHIC STATICS **Lectures and Drawing**

Credit two hours.

In this course instruction is given in graphical analysis of the stresses in framed structures of various kinds. The trusses include Howe, Pratt, Fink, crescent, grand stands, hinged arches, mill buildings with both ends fixed, a gravity masonry arch, and bridges of various kinds. Arrangements of floor loads for maximum stresses are determined. The student is required to determine and tabulate dead, snow, and wind load stresses in trusses and to combine them so as to determine the maxima and minima. Sections of the gravity arch are drawn and dimensioned so that the line of thrust is within the middle third of the arch ring loaded variously.

Prerequisite: This course is intended primarily for regular members of the junior class and for post graduate students, but others may take it with the consent of the instructor.

Six hours a week during the first semester of the junior year.

Required in Group VIII. (Gardner)

VIII STRUCTURAL DESIGN **Lectures and Drawing.** (Elective)

Credit two hours.

This course follows Course VII. The student now uses the information gained in the previous courses in the complete design of a given structure. Mill building construction is discussed and the student is made familiar with terms of framing. Having given accepted allowable unit stresses, he is required to design a complete steel mill building, headframe, ore bin, or some other structure.

Prerequisite: Course VII

Six hours a week during the second semester of the senior year. (Gardner)

IX HYDRAULIC INVESTIGATIONS **Laboratory and Field Work** (Elective)

Credit two hours.

This is an advanced course in hydraulics, in which the student is shown how to make the more practical field investigations of water power and various other hydraulic installations. Practical problems omitted in previous courses because of their greater difficulty are here considered according to latest and best engineering practice. Pipe line problems met with in various engineering installations are taken up and solved. Several streams and water power sites are examined and reports on power available and feasibility of development are submittted. The student is made familiar, in the lecture room and in discussions, with the great variety of conditions which may affect any installation and its construction. From a study of various kinds of water wheels the student is made to understand the reason that certain types are adapted to certain conditions, and what are the main features which enter into their design. Finally the student is required to make a survey of a water power site, execute a map or drawing showing a complete general design and layout of installation, accompanied with a full report covering all details of design, power available, income of plant, initial and operative costs, and thus arrive at the charge to be made for power developed.

Prerequisite: Course V

Laboratory and field work six hours a week during the second semester of the senior year. (Gardner)

X PRINCIPLES OF REINFORCED CONCRETE **Lectures**

Credit two hours.

The course in reinforced concrete includes a study of the mechanics of the subject in which the student is required to derive all formulas involved, and to use them in the solution of problems and in the design of certain simple structures. The time allotted to the course permits a consideration of the entire subject including the assumption of both triangular and parabolic stress distribution; beams; columns; shear, bond and diagonal tension; chimneys; arch rings; and slabs. An effort is made to show the student how to trace out the lines of tensile stress, and to place the steel accordingly.

Prerequisite: Course III

Two hours a week during the second semester of the senior year.

Required in Group VIII. (Gardner)

XI TESTING LABORATORY

Credit one hour.

In this course practical application is made of the principles of elasticity, and the laws are verified. The student is enabled to visualize the effect of loads imposed on bodies of various materials and thereby to gain a practical knowledge of the strength and resistance of these materials. Tests of cement and aggregate for concrete are made in the usual way. The tests include those of the strength of concrete in compression and tension under various conditions of proportioning, mixing, and curing. Tests are also made on the various other kinds of building material.

Prerequisite: Course III

Three hours a week during the second semester of the junior year.

Required in Group VIII. (Gardner)

XII RAILWAY SURVEYING **Lectures and Field Work**

Credit two hours.

The course includes a study of the fundamental principles of railway curves, embankments, and cuts, and the performance of certain field exercises. Those enrolled are required to lay out simple curves, turnouts, spirals, and other accessories, and to set slope stakes and make an estimate for a proposed stretch of railroad.

Prerequisite: Course II.

Six hours a week during the first semester of the junior year.

Required in Group VIII. (Gardner)

XIII WOOD TECHNOLOGY **Lectures**

Credit two hours.

A course intended to give an engineer an idea of the elements of timber conservation; of the production, preservation, and use of lumber; of diseases of trees; and of the properties of different kinds of lumber.

Prerequisite: Course III.

Two hours a week during the second semester of the junior year.

Required in Group VIII. (Gardner)

XIV WATER SUPPLY **Lectures**

Credit two hours.

The course involves a study of the principles involved in providing potable water. The three general subdivisions of

the subject collection, purification, and distribution are discussed in their various phases.

Prerequisites: Course III, registration in Course V.

Two hours a week during the first semester of the senior year.

Required in Group VIII. (Gardner)

XV SEWERAGE **Lectures**

Credit two hours.

A general survey of sanitary sewerage. The course includes a consideration of the problems involved in sewage collection, sewer construction, and sewage disposal by the various methods now in use. Considerable stress is placed on the biological aspect of sewage treatment.

Prerequisite: Course XIV.

Two hours a week during the second semester of the senior year.

Required in Group VIII. (Gardner)

XVI MASONRY **Lectures**

Credit three hours.

The course considers the phases of masonry that an engineer is likely to meet. The phases include studies of the manufacture and use of cement and artificial stone, concrete, brick, and other petrean materials; the quarrying and dressing of natural stone; classifying stone and brick masonry; testing petrean materials; and designing and constructing culverts, conduits, footings, foundations, retaining walls, and arches.

Prerequisite: Course IV.

Three hours a week during the first semester of the senior year.

Required in Group VIII. (Gardner)

XVII FRAMED STRUCTURES **Lectures**

Credit three hours.

This is a course in the computation of stresses in framed structures. The structures analyzed include simple bridge trusses of various kinds, mill buildings, cranes, towers, cantilever trusses, suspension bridges, and arches.

Prerequisite: Course IV.

Three hours a week during the first semester of the senior year.

Required in Group VIII. (Gardner)

XVIII CONTRACTS AND SPECIFICATIONS **Lectures**

Credit two hours.

A course intended to give the student a conception of the elementary principles involved in preparing and interpreting specifications for engineering structures, and of the elements that constitute a valid contract.

Prerequisite: This course is intended primarily for regular members of the senior class, and for post graduates, but others may take it with the consent of the instructor.

Two hours a week during the second semester of the senior year.

Required in Group VIII. (Gardner)

DESCRIPTIVE GEOMETRY AND TECHNICAL DRAWING

Joseph Francis O'Byrne, Professor
George W. Salzer, Assistant Professor.

I DESCRIPTIVE GEOMETRY **Lectures**

These lectures include the sixteen fundamental problems relative to the point, right line, and plane; the generation of lines and surfaces; and the solution of about ninety so-called original problems.

Prerequisites: Entrance requirements

Two hours a week during the first semester of the freshman year.

Required of all students. (O'Byrne)

II DESCRIPTIVE GEOMETRY **Drawing**

The student is taught the use of drawing instruments; the basic principles of free hand lettering; certain essential mechanical alphabets; the mechanical drawing of simple objects; and various applications of the subject matter given in the lectures.

Prerequisites: Entrance requirements

Six hours a week during the first semester of the freshman year.

Required of all students. (O'Byrne, Salzer)

III DESCRIPTIVE GEOMETRY AND ITS PRACTICAL APPLICATIONS **Lectures**

This course is a continuation of Course I, and includes the intersection and development of surfaces; shades and shadows; isometric projection; the solution of fault problems; intersection of veins; representation of mine workings; and the checking of underground surveys. At the conclusion of this work elementary machine design is taken up in preparation for the sophomore year.

Prerequisites: Courses I and II

Two hours a week during the second semester of the freshman year.

Required of all students. (O'Byrne)

IV DESCRIPTIVE GEOMETRY AND ITS PRACTICAL APPLICATIONS **Drawing**

Mechanical drawing is continued, but the further object is to teach the student the practical applications of descriptive

geometry in the solution of those problems he will meet continually in the field. In conclusion some time is devoted to dimensioning, and working drawings are submitted from a list comprising anchor-bolts, shaft-couplings, hangers, machine elements, and mine timbering.

Prerequisites: Courses I and II

Six hours a week during the second semester of the freshman year.

Required of all students. (O'Byrne, Salzer)

V TOPOGRAPHICAL DRAWING **Lectures and Drawing** (Elective)

Credit one hour.

The student is taught the use of conventional signs in field sketches and mapping; the horizontal systems of slope representation; the vertical systems of hill shading; the projection of meridians and parallels of latitude, and the enlargement and reduction of maps and plans.

Prerequisite: This course may be taken only with the consent of the instructor.

Three hours a week during the second semester of the junior year. (Salzer)

VI DESCRIPTIVE GEOMETRY APPLIED TO MINING **Lectures and Drawing** (Elective)

Credit two hours.

Problems similar to those in Course IV are obtained in the field, and are solved analytically and graphically.

Prerequisite: This course is intended primarily for regular members of the senior class, and for post graduate students, but others may take it with the consent of the instructor.

Six hours a week during the first semester of the senior year. (O'Byrne, Salzer)

VII METHODS OF TEACHING DESCRIPTIVE GEOMETRY AND TECHNICAL DRAWING **Lectures and Drawing** (Elective)

Credit six hours.

The students attend all work of Courses I, II, III, and IV, review the subject thoroughly, taking notes of methods of presentation, and are given practice in actual teaching of the subject. A concise set of typewritten notes on the work is required.

Prerequisite: This course may be taken only with the consent of the instructor.

Nine hours a week during the senior year, to be arranged by the instructor. (O'Byrne)

ELECTRICAL ENGINEERING

Arlington P. Little, Professor

The courses in Electrical Engineering are designed to give such training as shall enable the graduate to deal intelligently with the engineering problems that will arise in his professional career, particularly in the west. In these courses a thorough study is made of fundamental principles and their application to electrical engineering. Much emphasis is placed on the analysis and solution of typical engineering problems, and abundant practice is given in applying theory to the actual conditions met in engineering work. It is desirable that mining students elect courses I, II, III, IV, V, and VII. However, these courses have been made as independent of each other as practicable so that the student may have considerable freedom in the choice of his electrical subjects. Electrical methods are being adopted in a constantly enlarging field, and this is steadily increasing the demand for mining graduates who can perform or direct successfully the work of installing and operating the electrical equipment of mines, smelteries, and mills. Inspection trips to electric power plants, substations, and industrial plants are made regularly, in connection with the courses. The educational value of such visits of inspection is well recognized, and the industries of Denver afford opportunities for students to visit places of special interest.

I DIRECT CURRENT **Lectures**

Credit two hours.

This course includes a study of the principles underlying the design, construction, and operation of shunt, series, and compound direct current generators, motors, meters, switchboards, and auxiliary apparatus, field of application of each type, methods of connection and control, use and care of storage batteries, and the calculation of circuits.

Prerequisites: Physics III and IV

Two hours a week during the first semester of the junior year.

Required in Groups VI and VII. (Little)

II DIRECT CURRENT MACHINERY **Laboratory**

Credit one hour.

In this work the commercial types of voltmeters, ammeters, wattmeters, and watt-hour meters are studied and calibrated;

shunt, series, and compound generators and motors, including three wire and interpole machines, are studied and their important characteristics determined. Standard series-parallel mining locomotive controllers are wired up and used to operate two series motors. The efficiencies of various types of machines are determined and practice is given in the parallel operation of shunt and compound generators.

Prerequisite: Registration in Course I.

Three hours a week during the first semester of the junior year.

Required in Group VII. (Little)

III ALTERNATING CURRENTS **Lectures**

Credit two hours.

The plan of this course is similar to that of Course I, but treats of alternating current principles and the characteristics of alternating current generators, motors, transformers, rectifiers, and converters, together with their auxiliary control apparatus, and the calculation of single-phase, two-phase, and three-phase circuits.

Prerequisites: Physics III and IV

Two hours a week during the second semester of the junior year.

Required in Group VII. (Little)

IV ALTERNATING CURRENT MACHINERY **Laboratory**

Credit one hour.

A study is first made of the alternating current instruments which are subsequently used in the experimental work. This is followed by a variety of experiments on inductive circuits. Transformers are connected and used in many ways. The starting and running characteristics of induction motors are studied under normal conditions and under some abnormal conditions that are frequently the cause of trouble. Practice is given in synchronizing and operating alternators in parallel.

Prerequisite: Registration in Course III

Three hours a week during the second semester of the junior year.

Required in Group VII. (Little)

V ELECTRICAL EQUIPMENT **Lectures** (Elective)

Credit two hours.

Calculations of power distribution circuits and the characteristics of electrical machines and auxiliaries are discussed and problems based upon this study are given. The applications considered include power plants, machine shop and factory equipment. As applied to mining, a study is made of

motor driven air compressors, fans, drills, coal cutters, shot-firing, lighting, haulage, hoisting, pumping, dredging, and signalling. The metallurgical applications include motor driven equipment, the production of current for electrolytic and electrothermal processes, magnetic separation, electrostatic separation, and precipitation. These subjects are, of course, discussed in detail by the special departments concerned and only the electrical features are considered in this course.

Prerequisites: Physics III and IV.

Two hours a week during the first semester of the senior year. (Little)

VI APPLIED ELECTRICITY **Laboratory** (Elective)

Credit two hours.

This course includes a study of hand operated compensators with no voltage and overload releases, resistance starters, motor-driven fans, and various tests of generators and motors.

Prerequisites: Courses II and IV. Registration in Course V.

Six hours a week during the first semester of the senior year. (Little)

VII ELECTRICAL INSTALLATIONS **Lectures** (Elective)

Credit two hours.

The subjects taken up in this course are: the circuits of electrical installations; safety, continuity of service, and cost of power; alternating and direct current motor characteristics, speed regulation and control; motor-generators, converters and rectifiers; transformer, auto-transformer, and regulating transformer characteristics; circuit breakers and lightning arresters; measuring and indicating apparatus; motor applications and costs.

Prerequisites: Physics III and IV

Two hours a week during the second semester of the senior year. (Little)

VIII ELECTRICAL INSTALLATIONS **Drawing** (Elective)

Credit two hours.

This is primarily a design course in mine and mill installations, although the work may be varied to suit the needs of the individual student.

Prerequisite: Registration in Course VII

Six hours a week during the second semester of the senior year. (Little)

IX ELECTRIC POWER PLANTS **Drawing**

Credit one hour.

This course includes the study of modern practice in the electrical equipment of steam electric and hydroelectric power

plants. A study is made of the fundamental considerations involved in selecting the units best adapted to particular conditions, in order to combine efficiency in operation and continuity of service with as low first cost as practicable. The construction and use of the various types of switchgear, essential measuring instruments, indicators, voltage regulators, and protective devices are taken up and discussed from the engineering point of view. The course is largely practice in the design of the electrical part of the power plant equipment and involves making working drawings of plant layout, including circuit diagrams from the generating units through the switchboard and transformers to the outside lines.

Prerequisites: Courses I and III.

Three hours a week during the first semester of the senior year.

Required in Group VII. (Little)

X POWER TRANSMISSION LINES AND SUBSTATIONS **Drawing**

Credit one hour.

This course is a study of the high voltage lines, insulators, towers, and line protective devices used in transmitting electrical power from the generating station to the mines, and includes the substation with its transformers, rotary converters, motor generator sets, and other apparatus required to change the voltage, phase, or frequency of the current to that desired for local distribution. This course also includes finding the most economical size of wire to use under given condition, determining the proper transmission voltage and spacing of the wires, selecting insulators, finding the best height and spacing of poles or towers, and the design of a substation.

Prerequisites: Courses I and III.

Three hours a week during the second semester of the senior year.

Required in Group VII. (Little)

XI ELECTRICITY IN ELECTROCHEMICAL AND ELECTROTHERMAL PROCESSES **Lectures**

Credit one hour.

This course takes up the fundamentals of electrochemistry and their application to electrochemical processes, special emphasis being placed on the electrical features involved. The production of the heat and the control of temperature in the electric furnace is studied, and a furnace designed.

Prerequisites: Physics III and IV.

One hour a week during the first semester of the junior year.

Required in Group VII. (Little)

XII PRIMARY AND STORAGE BATTERIES **Lectures**

Credit one hour.

A study is made of the theory of operation of primary and secondary batteries including standard cells, electrical characteristics, action of depolarizers, and effect of temperature on the electromotive force and internal resistance of cells. The selection of a battery for a particular purpose and the care of batteries in service are also carefully studied.

Prerequisites: Physics III and IV

One hour a week during the second semester of the junior year.

Required in Group VII. (Little)

XIII ELECTRICAL MACHINE DESIGN **(Direct Current) Drawing**

Credit one hour.

Design of direct current generators and motors, series, shunt, and compound; interpole and non-interpole types.

Prerequisites: E. E. I and II.

Three hours a week during the first semester of the senior year.

Required in Group VII. (Little)

XIV ELECTRICAL MACHINE DESIGN **(Alternating Current) Drawing**

Credit one hour.

Design of alternators and synchronous motors of the revolving field and revolving armature types; transformers for power and lighting, of the core and shell types for single and three phase circuits.

Prerequisites: E. E. III and IV.

Three hours a week during the second semester of the senior year.

Required in Group VII. (Little)

XV ILLUMINATING ENGINEERING **Lectures** (Elective)

Credit one hour.

This is a study of photometric methods, lamps, shades, and reflectors; selection and arrangement of units; calculation of light flux, and illumination intensity; design and comparison of illuminating systems for lighting streets, factories, offices, mines, and mills.

Prerequisites: Physics III and IV.

One hour a week during the second semester of the junior year. (Little)

XVI ELECTRIC RAILWAY ENGINEERING Lectures

Credit two hours.

This course is a study in detail of systems of power distribution for electric railways; alternating versus direct current for traction work; train diagrams and speed-time curves; energy costs; electric railway power plants and substations; steam versus electricity; electrification of steam roads; performance of railway equipment, and its application to urban, suburban, interurban, and heavy electric traction.

Prerequisites: Courses I and III.

Two hours a week during the first semester of the senior year.

Required in Group VII. (Little)

XVII ADVANCED ALTERNATING CURRENTS Lectures

Credit one hour.

A continuation of Course III, dealing with more advanced work in alternating current theory applications.

One hour a week during the second semester of the senior year.

Required in Group VII. (Little)

XVIII ELECTRICAL SEMINAR

Credit one hour.

This course includes a digest of articles in current engineering magazines, and the transaction of the American Institute of Electrical Engineers.

One hour a week during the first semester of the senior year.

Required in Group VII. (Little)

XIX ELECTRICAL SEMINAR

Credit one hour.

This is a continuation of Course XVII.

One hour a week during the second semester of the senior year.

Required in Group VII. (Little)

ENGLISH

Victor C. Alderson, President

I ENGLISH COMPOSITION **Lectures**

Credit one hour.

This course is designed to train the student in the essentials of English composition. Practical exercises are given to develop orderly arrangement and clear expression of thought. A study is made of the relation of the general to the particular and its practical application in writing paragraphs and subject outlines.

One hour a week during the first semester of the junior year.

Required of all students. (Alderson)

II BUSINESS CORRESPONDENCE **Lectures**

Credit one hour.

This course is a continuation of Course I. It aims to give a practical grasp of business correspondence and to familiarize the student with the type of English composition requisite as a basis for business correspondence.

One hour a week during the second semester of the junior year.

Required of all students. (Alderson)

III REPORTS **Lectures**

Credit one hour.

This course is designed as a preparation for technical writing. The fundamentals of the subject are studied and reports upon assigned topics are required from the students.

One hour a week during the first semester of the senior year.

Required of all students. (Alderson)

IV TECHNICAL WRITING **Lectures**

Credit one hour.

This course is a continuation of Course III. The principal object is to outline the best methods of presenting technical subjects for publication and for private reports.

One hour a week during the second semester of the senior year.

Required of all students. (Alderson)

V ASSEMBLY **Lectures**

This course consists of a series of informal talks to freshmen

One hour a week during the first semester of the freshmar year.

Required of all students. (Alderson)

VI ASSEMBLY **Lectures**

This is a continuation of Course V.

One hour a week during the second semester of the freshman year.

Required of all students. (Alderson)

FINANCE

Victor C. Alderson, President
Dean Grant, Professors Palmer and Underhill

I FINANCE **Seminar** (Elective)

Credit one hour.

It is a well-known fact that engineers frequently fail to appreciate the financial aspect of their work. To obviate this defect the course is offered in the form of a seminar. Attention is called to the great world movements that cause variations in the market value of securities, the minor market movements, and the general trend of the prices of commodities. Special attention is given to a discussion of current events and their bearing upon the stock market and economic conditions. Members of the class follow closely the market value of a group of selected securities on the New York Stock Exchange, offered below, or at its real value. The Wall Street Journal, the Magazine of Wall Street, John Moody's Investment Service, Babson, besides many works on finance are available in the Library. A strong effort is made to get the student interested in financial matters, to induce him to read financial literature, and to form his own opinion of the results of the forces at work to determine the market value of securities.

One hour a week during the first semester of the senior year.

This course may be taken only with the consent of the instructor. (Alderson, Grant, Palmer, Underhill)

II FINANCE **Seminar** (Elective)

Credit one hour.

This is a continuation of Course I.

One hour a week during the second semester of the senior year. This course may be taken only with the consent of the instructor. (Alderson, Grant, Palmer, Underhill)

FRENCH

C. Desmartin, Instructor in Modern Languages

I FRENCH ELEMENTARY (Elective)

Credit two hours.

Conversation. The only method by which a modern language can be learned is by talking. This method is rigorously pursued.

Pronunciation. The correct pronunciation of a modern language is vital and can be acquired only by constant practice in conversation.

Grammar. Sufficient grammar is taught to enable the student to use the ordinary forms of the language correctly.

Prerequisite: This course is intended primarily for juniors but others may take it with the consent of the instructor.

Two hours a week during the first semester of the junior year. (Desmartin)

II FRENCH ELEMENTARY (Elective)

Credit two hours.

Conversation. This is continued as in Course I.

Grammar. The conjugation of the regular verbs and of the frequently used irregular verbs is studied and applied in oral and written exercises.

Correspondence. Social and commercial letters are composed and translated from English into French and from French into English.

Prerequisite: Course I

Two hours a week during the second semester of the junior year. (Desmartin)

GEOLOGY

F. M. Van Tuyl, Professor
James J. Lillie, Assistant Professor
J. Harlan Johnson, Assistant Professor
Sidney A. Packard, Fellow
Ronald K. DeFord, Fellow
George W. Machamer, Fellow

The college is very fortunately situated for the teaching of geology. The surrounding formations present the strikingly clear features so characteristic of the West. It is possible, without going more than a mile or two from the school, to illustrate very effectively most geological phenomena so that field geology can be carried on at the same time as class instruction. In addition certain features peculiar to this particular location afford sufficiently complicated problems to be of great value to the advanced student of geology.

I GENERAL GEOLOGY **Lectures**

The aim of this course is to present the fundamentals of geology by means of lectures supplemented by the study of the textbook, and by assigned readings. It comprises a brief survey of the rocks and minerals of the earth's crust and a comprehensive study of the surface features of the earth, with emphasis on the forces and agents which have produced these results and are still bringing about slow changes. Short field trips are required.

Prerequisite: Entrance requirements

Lectures two hours a week during the first semester of the freshman year.

Required of all students. (Lillie, Johnson)

II GENERAL GEOLOGY **Lectures**

This course is a continuation of Course I. It is a study of primary and secondary rock structures, with emphasis on the secondary features resulting from earth movements, such as faults and folds, and the value of their proper interpretation to the mining engineer. Short field trips are required.

Prerequisite: Course I

Lectures two hours a week during the second semester of the freshman year.

Required of all students. (Lillie, Johnson)

III MINERALOGY **Lectures and Laboratory**

This course in mineralogy is essentially an introduction to Descriptive Mineralogy of the second semester. It comprises a discussion of the principles of crystallography and of blowpipe analysis. Only such portions of crystallography are emphasized as are of practical value in the determination and proper understanding of minerals. In the laboratory work a very thorough drill is given in the more practical portions of the subject. The course includes work with wooden crystal models, and the determination of the forms on a large and representative series of natural crystals. The laboratory work in crystallography is followed by a thorough drill in the methods of blowpipe analysis, with practice in the determination of unknown minerals.

Prerequisites: Chemistry I and II

Lectures two hours, laboratory six hours, a week during the first semester of the sophomore year.

Required of all students. (Van Tuyl, Lillie, Johnson)

IV DESCRIPTIVE MINERALOGY **Lectures and Laboratory**

About three hundred of the more important mineral species are presented by lectures, in which special emphasis is placed on the recognition of minerals by means of their physical properties. Every attempt is made to make the course thoroughly practical so as to enable the student to recognize at sight such minerals as are met in mining operations. With this object in view, as thorough a drill as the time will allow is given to the actual handling and determining of minerals in the laboratory. In this work each student is expected to handle, to determine, and to be questioned and examined on approximately two thousand five hundred individual specimens.

Prerequisite: Course III

Lectures two hours, laboratory six hours, a week during the second semester of the sophomore year.

Required of all students. (Van Tuyl, Lillie, Johnson)

V HISTORICAL GEOLOGY **Lectures**

Credit two hours.

A study of earth history with emphasis on the North American continent. The theories of the origin of the earth are discussed and the succession of events in its known history as revealed by the rocks are traced. Special attention is given to the changes in relation of land and sea, the character and distribution of the deposits, the orogenic movements, volcanic activity, and economic products of each geological period. An effort is made to show clearly the many changes which have

taken place in life on the earth during its gradual evolution to the forms of today.

Prerequisites: Courses I and II

Lectures two hours a week during the first semester of the junior year.

Required in Group IV. (Johnson)

VI STRUCTURAL GEOLOGY **Lectures**

Credit two hours.

This course covers practically mining geology. It includes a comprehensive study of rock structures with special emphasis on features important to the mining engineer. The graphic study of folds and faults and the interpretation of structure from maps receive special attention.

Prerequisites: Courses I to IV inclusive.

Lectures two hours a week during the first semester of the junior year.

Required in Groups IV and V. (Lillie)

VII PETROLOGY **Lectures and Laboratory**

Credit two hours.

The object of this course is to present all the more common rocks in such a way as to render their identification at sight reasonably accurate. The methods pursued are purely those applicable to the hand specimen without the aid of microscopic sections. The collection of the school is especially rich in those rocks that are usually encountered in mining operations in Colorado and adjacent states. Special emphasis, therefore, is laid upon such rocks and upon their various alteration forms.

Prerequisite: Course IV

Lectures one hour, laboratory three hours, a week during the second semester of the junior year.

Required in Groups I and IV. (Van Tuyl, Lillie)

VIII MICROSCOPIC PETROGRAPHY

Credit two hours.

In this course the study of rocks and rock forming minerals is carried on with the aid of the petrographic microscope. It covers (a) the study of the optical properties of minerals with a view to their identification, and (b) systematic petrography or the identification of rock types by means of their structures and mineral components.

Prerequisite: This course is intended primarily for those who select Group IV. Others may take it as an elective, only with the consent of the instructor.

Six hours a week during the first semester of the senior year.

Required in Group IV. (Van Tuyl)

IX INDEX FOSSILS OF NORTH AMERICA **Lectures and Laboratory**

Credit two hours.

A course planned to meet the needs of students who desire to fit themselves for work in oil geology and stratigraphy. Only the more important guide fossils of each system are studied. Special attention is given to the fossils characteristic of western formations of economic importance.

Prerequisite: This course is intended primarily for those who select Group IV. Others may take it as an elective only with the consent of the instructor.

Six hours a week during the second semester of the senior year.

Required in Group IV. (Van Tuyl)

X ORE DEPOSITS **Lectures**

Credit two hours.

This course treats of the nature, origin, and occurrence of ore deposits. Among other subjects the criteria useful in the recognition of the various types of ore deposits, the changes in the character of ores with depth, and mineral associations and alterations are discussed. Those features likely to be of use in the examination of mining prospects receive special attention.

Prerequisites: Courses I, II, III, IV, and VII

Lectures two hours a week during the first semester of the senior year.

Required in Groups I and IV. (Van Tuyl)

XI ECONOMIC GEOLOGY **Lectures**

Credit two hours.

This course includes a discussion of the more important mining districts of North America. In addition to ore deposits, the more important non-metallic products and their distribution are included.

Prerequisite: Course X

Lectures two hours a week during the second semester of the senior year.

Required in Groups I and IV. (Van Tuyl)

XII GEOLOGY OF OIL AND GAS **Lectures**

Credit two hours.

The chemistry and physics of the natural hydrocarbons and their origin and mode of occurrence are discussed in detail. The age of the formations and the structure of the important oil and gas fields of North America are then considered. Some time is

also devoted to the oil shale industry. Finally, the methods of oil and gas prospecting are outlined.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor.

Two hours a week during the second semester of the senior year.

Required in Group IV. (Van Tuyl)

XIII FIELD GEOLOGY

Credit two hours.

This course is intended to give field practice in geologic mapping and in the working out of structural details. The area selected is divided among individual squads and a complete map with structural sections is prepared through cöoperation of the different squads. The work covers two weeks at the close of the junior year. Camping equipment and instruments are furnished by the school. The student is expected to furnish bedding. The expense of the course varies somewhat according to the location of the area worked. Ordinarily forty to forty-five dollars should cover all actual field expenses.

Prerequisites: Courses V, VI, VII, and XIV.

Two weeks of the summer at the close of the junior year.

Required in Group IV. (Van Tuyl, Lillie, Johnson)

XIV GEOLOGICAL SURVEYING Lectures and Field Work

Credit one hour.

This course is devoted to the study and practical application of the various methods of reconnaisance and detailed geologic mapping. It embraces a discussion of the types of geological instruments and the merits of each for particular surveys, actual practice in mapping in the vicinity of Golden and, finally, experience in the preparation of geological sections and reports.

Prerequisite: This course is intended primarily for regular members of the junior class, but others may take it with the consent of the instructor.

Three hours a week during the second semester of the junior year.

Required in Group IV. (Lillie)

XV. OIL FIELD DEVELOPMENT. Lectures

Credit one hour.

This course involves a study of the forms of oil and gas leases, the economic and geologic factors influencing the location of test wells, and the development of drilling; the methods of determining the probable depth to "pay" sands and the cost of

drilling; the interpretation of well logs and the construction of structure contour maps; the methods of determining the probable life of oil wells and their total production; the valuation of oil properties.

Prerequisite: Course XII

One hour a week during the second semester of the senior year.

Required in Group IV. (Van Tuyl)

XVI INTERPRETATION OF MAPS **Laboratory**

Credit two hours.

This course, which is based largely on the topographic and geologic maps and folios of the United States Geological Survey, is primarily a laboratory course supplemented by occasional lectures and assigned readings. By bringing the field to the laboratory by means of the maps and folios, the student is given an opportunity to apply many of the geologic field methods used in the working out of the physical and geological history of a region. The maps and folios have been so selected that all of the important types of topography and geologic structures are represented. The course aims to enable the student to interpret at a glance the physical and geological history of a region represented, to give him greater familiarity with the geologic methods used in the determination of rock structure, and, in some degree, to acquaint him with the distribution of the various geologic systems in the United States. The course is divided into two parts, viz., topographic map exercises and geologic map exercises.

Supplementary work is also given with maps of foreign surveys, especially British and French, to familiarize the student with the different systems of conventions used.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor

Laboratory six hours a week during the first semester of the senior year.

Required in Group IV. (Johnson)

XVII GEOLOGICAL SEMINAR (Elective)

Credit one hour.

In this course the current literature on geology and mineralogy is reviewed, and reports on original investigations by the faculty and by students in geology are presented. Each student who registers for the course will appear on the program at least twice during the semester.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor

One hour a week during the first semester of the senior year. (Van Tuyl)

XVIII GEOLOGICAL SEMINAR (Elective)

Credit one hour.

A continuation of Course XVII. In addition to the presentation of reviews and reports on original investigations, discussions of special problems of interest to the members of the class are encouraged.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor

One hour a week during the second semester of the senior year. (Van Tuyl)

XIX GEOLOGICAL RESEARCH (Elective)

All students specializing in mining geology are urged to prepare a thesis during their senior year on some geological subject acceptable to the head of the department under whose supervision the investigation is carried on. The credit allowed depends upon the nature of the problem selected and the amount of time required for its solution and the preparation of a suitable report.

Hours will be arranged. (Van Tuyl)

XX THE WORLD'S MINERAL RESOURCES (Elective)

Credit one hour.

In this course a general study is made of the mineral resources of the world. The relative importance of the mineral deposits of the different countries is considered, as is their exploitation and the commerce in their products. The geology of the several deposits is briefly discussed. Special attention is given to the mineral resources of North America.

Prerequisite: This course is intended primarily for regular members of the senior class, and for post graduate students, but others may take it with the consent of the instructor.

Lectures, one hour a week during the first semester of the senior year. (Johnson)

XXI POLITICAL AND COMMERCIAL GEOLOGY (Elective)

Credit one hour.

This course is intended to give a general idea of the geographical location, extent, and political and economic control

of the important mineral deposits of the world. Consideration is also given to the trade routes used in their exploitation.

Prerequisite: This course is intended primarily for members of the senior class, and post graduates, but others may take it with the consent of the instructor.

Lectures, one hour a week during the second semester of the senior year. (Johnson)

HYGIENE AND CAMP SANITATION

Capt. Walter E. Lorence, Professor of Military Science and Tactics

I HYGIENE AND CAMP SANITATION **Lectures** (Elective) Credit two hours.

General principles of personal and public hygiene; preventive measures and prophylaxis; industrial hygiene with special regard to mining camps and mills; camp sanitation, sewage, and garbage disposal, water supply, and general health measures.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor

Two hours a week during the first semester of the senior year. (Lorence)

MATHEMATICS

George Wollam Gorrell, Professor
George G. Hubbard, Assistant Professor

The courses in this department have been arranged to meet the extensive needs of students in the various branches of engineering. The subjects are treated so as to give the student both logical training and power of application. The principles which are of greatest value in engineering work are particularly emphasized. The courses offered serve as a sufficient prerequisite for the work in mathematical physics, physical chemistry, engineering and applied mechanics; and they mark the minimum of mathematical attainments that an engineer ought to possess. A special feature of the work is the early introduction of the calculus, the principles of which are introduced with those of analytic geometry and developed as needed, so that, to a certain extent, the traditional barrier that has existed between these subjects, is disregarded. By this means, the principles of the calculus are allowed to develop slowly, their sphere of usefulness is widened, the student gains a better grasp of mathematics as a whole, and is able, early in his course, to make direct application of his knowledge of mathematics to practical problems.

I ELEMENTARY ANALYSIS

The work of the first year consists of the study and correlation of the most important parts of algebra, trigonometry, and analytical geometry, together with an introduction to the calculus. The usual plan of studying these topics separately is not followed, the order of topics depending rather upon their natural sequence and relative difficulty. By such a plan the student obtains a clearer grasp of the inter-relation of subjects.

Usually there is given at the beginning of the first semester a brief review of a few of the most important topics of elementary algebra, while others are taken up later as their need becomes evident. Functions and their graphs are then introduced and they recur from time to time throughout the year. This study prepares the way for other subjects which follow. Trigonometric functions are taken up and applied to the solution of problems. At first the natural functions are used in calculations, as experience has shown that the student thus obtains a clearer notion of the trigonometric relations. Then when logarithms are studied and applied it is realized that their use

constitutes a method of computation. The greater portion of trigonometry is completed in the first semester, but a few topics are reserved for later consideration. Some of the simpler topics in coordinate geometry are taken in this semester.

Prerequisite: Entrance requirements.

Five hours a week during the first semester of the freshman year.

Required of all students. (Gorrell, Hubbard)

(This course is repeated in the second semester.)

II ELEMENTARY ANALYSIS

This is a continuation of Course I. Analytical geometry is continued and calculus introduced. Certain topics in algebra and trigonometry, not covered in the first semester, are taken, such as the solution of higher equations, polar coordinates and periodic trigonometric functions. The fundamental principles of analytical geometry and the differential calculus are carefully considered and applied to practical problems.

Prerequisite: Course I.

Five hours a week during the second semester of the freshman year.

Required of all students. (Gorrell, Hubbard)

V CALCULUS

A thorough review is given of the work done in calculus in the freshman year. A special feature of this course consists in carrying on the differential and integral calculus together. This method of instruction enables the student to grasp the more difficult notions of the subject in their inherent relations, and at the same time to apply this knowledge, early in the course, to the solution of engineering problems. The conception of the definite integral and its many applications are early introduced. The aim is to make clear the *rationale* of each process, and to arouse an early interest in the usefulness of the subject. The theory of single and multiple integration is applied to the principal methods of rectification and quadrature, and to the calculation of surfaces and volumes of solids of revolution.

Prerequisites: Courses I and II.

Three hours a week during the first semester of the sophomore year.

Required of all students. (Gorrell, Hubbard)

(This course is repeated in the second semester.)

VI CALCULUS

This course is a continuation of Course V. The elements of solid analytic geometry are introduced to assist in the proper de-

velopment of the calculus of functions of two or more variables. Simple differential equations are introduced in close connection with integration. Multiple integration in rectangular, polar, and cylindrical co-ordinates is taken up and many applications are made to problems in areas, volumes, moments of inertia, centers of gravity, and pressure. Solids of revolution, cylinders, space curves, ruled and quadric surfaces are all given their needed emphasis as applications of the calculus. The last part of this course is pre-eminently a problem course. The aim is to review, in a practical way, the mathematics of the last two years and thereby encourage the student to look upon his mathematics as an instrument of power and usefulness, rather than one merely of mental development and culture.

Prerequisite: Course V

Three hours a week during the second semester of the sophomore year.

Required of all students. (Gorrell, Hubbard)

VII MECHANICS

This course is devoted to statics. Among the topics considered are equilibrium of forces and their application to structures of different kinds, centroids and centers of gravity, and moments of inertia. A marked feature of the course is the application of the graphic method to the solution of problems, which is used in connection with the algebraic method. Many problems are taken from engineering sources.

Prerequisites: Mathematics V and VI, Physics I and II

Two hours a week during the first semester of the junior year.

Required of all students. (Gorrell, Hubbard)

VIII MECHANICS

This is a continuation of Course VII, and consists of work in kinetics. A brief review is given on the fundamental conceptions of force, mass, weight, velocity, and acceleration. The different types of motion are thoroughly discussed, and their applications considered in the solution of many practical problems. Other topics taken up are work and energy, friction, impulse, momentum and impact.

An effort is made in Courses VII and VIII to show the engineering student how mathematics may be used as a tool in his work.

Prerequisite: Mathematics VII

Two hours a week during the second semester of the junior year.

Required of all students. (Gorrell, Hubbard)

MECHANICAL ENGINEERING

James Lyman Morse, Professor
Prentiss F. Brown, Fellow

The work of the mechanical engineering courses is intended to acquaint the student with the fundamental principles underlying engineering practice, and to impress upon his mind the importance of sound theory as the basis of reasoning in the analysis of practical engineering problems. The development of the reasoning faculties, and the knowledge of the sources upon which to draw for the desired information, necessarily takes precedence over the mere acquisition of knowledge.

V KINEMATICS OF MACHINERY **Lectures and Problems**

This course begins with the theoretical analysis of mechanism and extends to the practical applications of these principles. Practical problems are assigned throughout the course. Special attention is given to the analysis of shop, mine, and mill machinery, and includes linkages, belting, cams, gears, and various other mechanisms.

Prerequisites: Des. Geom. III and IV.
Math. II.

One hour a week during the first semester of the sophomore year.

Required of all students. (Morse)

VI KINEMATICS OF MACHINERY **Drawing**

This course supplements and is directly dependent upon the lecture work. This work is taken up from a practical point of view and applies such theory as is consistent with good practice. Outline drawings are made of linkages, cams, gears, variable motion transmissions, and various other mechanisms found in practice. Special attention is given to the coordination of relative velocity, motion, and balance of parts.

Prerequisites: Des. Geom. III and IV.
Math. II.

Three hours a week during the first semester of the sophomore year.

Required of all students. (Morse)

VII MACHINE DESIGN **Lectures and Problems**

This course includes a brief outline of the mechanics and physics involved in the analysis of the stresses and strains induced in machine elements by the work they perform. The size

and shape of parts and the materials from which they are made are considered in detail. Practical problems in design, based upon first class engineering practice, constitute an important feature of the course.

Prerequisites: Courses V and VI.
Math. V.
Phys. I and II.

One hour a week during the second semester of the sophomore year.

Required of all students. (Morse)

VIII MACHINE DESIGN **Drawing**

This course comprises the drafting room work of Course VII and consists of working drawings of various machine elements previously analyzed and calculated in Course VII. Only practical design drawings which conform to good commercial practice are considered and are selected from the equipment of the mine, mill, and factory.

Prerequisites: Courses V and VI.
Math. V.
Phys. I and II.

Three hours a week during the second semester of the sophomore year.

Required of all students. (Morse)

IX ENGINEERING DESIGN **Lectures**

Credit one hour.

This course includes the fundamental theory of machine design, considered both from the analytical and empirical standpoint. The subject matter includes the analysis of such mechanical equipment as may be found in mine plants, mills, transportation systems, and factories. Numerous practical problems are assigned throughout the course for the purpose of training the student to exercise judgment in the selection of data to be used in the solution of design problems.

Prerequisites: Courses VII and VIII.
Registration in M. E. XXIV, and Math. VII.

One hour a week during the first semester of the junior year.

Required in Group VI. (Morse)

X ENGINEERING DESIGN **Drawing**

Credit one hour.

This course includes the drafting room work of Course IX, and consists of the production of working drawings of complete machines and parts. Trade catalogs are used in conjunction

with text and reference books for the purpose of acquainting the student with commercial practice. The importance of economic production, operation, and first cost is emphasized.

Prerequisite: Registration in Course IX.

Three hours a week during the first semester of the junior year.

Required in Group VI. (Morse)

XI ENGINEERING DESIGN **Lectures**

Credit one hour.

This course is a continuation of Course IX, and consists of advanced work in the theory of machine design.

Prerequisites: Courses IX, X, and XXIV.

One hour a week during the second semester of the junior year.

Required in Group VI. (Morse)

XII ENGINEERING DESIGN **Drawing**

Credit one hour.

This course is a continuation of Course X, and includes a more advanced degree of design drawing.

Prerequisite: Registration in Course XI.

Three hours a week during the second semester of the junior year.

Required in Group VI. (Morse)

XIII COMPRESSED AIR **Lectures and Problems** (Elective)

Credit two hours.

This course includes a study of the theory and practice of air compression. At the beginning considerable time is given to the study of such thermodynamics as is necessary to a successful pursuit of the course. After this the work comprises a study of the following principal subjects: single and multiple stage compression; hydraulic compression; absorption of heat during compression; transmission of power by compressed air; draining of moisture from pipe lines; reheating; the use of compressed air in motors and the various valve gears used; the application of compressed air to pumping, hoisting, drilling, and conveying.

Prerequisites: Courses VII and VIII.
Math. VI.
Physics III and IV.

Two hours a week during the first semester of the senior year. (Morse)

XIV POWER PLANT DESIGN Lectures and Problems

Credit two hours.

This course includes a detailed study of the units and auxiliaries necessary to a power plant and their various connecting links. Conditions affecting the type and location of power plants are considered and the work extended to problems involving the best selection and number of units, their location and arrangement, connection with auxiliaries, and the necessary housing for equipment. The items of first cost, operating cost, and depreciation are carefully considered.

Prerequisites: Courses VII, VIII, and XIX.
Math. VI.
Physics III and IV.

Two hours a week during the first semester of the senior year.

Required in Group VI. (Morse)

XV POWER PLANT DESIGN Drawing

Credit two hours.

The work in this course includes working drawings of some of the power plant equipment taken up and studied in detail in Course XIV. Such problems as the following are assigned: detail of piping systems, including live and exhaust steam, for a certain size plant; foundations for units and auxiliaries; flues and stacks; coal and ash handling machinery, and complete power plants.

Prerequisites: Courses VII, VIII, and XIX.
Math. VI.
Physics III and IV.

Six hours a week during the first semester of the senior year.

Required in Group VI. (Morse)

XVI INTERNAL COMBUSTION ENGINES Lectures

Credit two hours.

This course is intended to give the student both a theoretical and practical knowledge of the internal combustion engine. The theory and thermodynamics of the engine are carefully considered together with the conditions affecting efficiency and operation. The best types of modern engines together with auxiliary apparatus are taken up and discussed with regard to special features and advantages. Catalogues and blue prints are freely used for the purpose of acquainting the student with the practical applications of internal combustion to the production of power.

Prerequisites: Courses VII and VIII.
Math. VI.
Physics III and IV.

Two hours a week during the first semester of the senior year.

Required in Group VI. (Morse)

XVII PUMPING MACHINERY **Lectures** (Elective)

Credit two hours.

This course includes a study of the principles, design, and operation of various kinds of pumping machinery. Special attention is given to the selection and installation of steam, electric, and compressed air pumps for mine service. Problems involving the calculations of capacity, slip, and duty of pumping engines are assigned to the students. Test and operating data from actual installations constitute an important feature of the course.

Prerequisites: Courses VII and VIII.
Math. VI.
Physics III and IV.

Two hours a week during the second semester of the senior year. (Morse)

XVIII MECHANICAL ENGINEERING **Laboratory**

Credit two hours.

It is the purpose of this course to familiarize the student with the apparatus used in testing power plants. The practice work includes indicator practice; study of reducing motions; dynamometers; determination of the quality of steam; flue gas analysis; calibration of gages; indicators; valve setting; testing of boilers, engines, turbines, and air compressors. A complete written report of each test or experiment is required of all students taking this work.

Prerequisites: Courses VII, VIII, XIII, XIX, and XX.

Six hours a week during the second semester of the senior year.

Required in Group VI. (Morse)

XIX HEAT POWER PLANT ENGINEERING **Lectures**

Credit two hours.

The work of this course is devoted principally to the consideration of the steam power plant, including the auxiliaries incident to a modern installation. The subject is considered both from the theoretical and practical standpoint. Problems relating to economy of operation, power output, and correct proportions of various elements of the plant, constitute a prominent feature of the course.

Prerequisites: Courses VII and VIII.
Math. VI.
Physics III and IV.

Two hours a week during the second semester of the junior year.

Required in Group VI. (Morse)

XX THERMODYNAMICS **Lectures and Problems**

Credit two hours.

A study of the laws and properties of gases and vapors as applied to heat engines, compressors, refrigerating machinery, heating and ventilating. Numerous practical problems are assigned for the purpose of illustrating the application of the theory to practice.

Prerequisites: Courses M. E. VII and VIII.
Math. VI.
Physics III and IV.

Two hours a week during the second semester of the junior year.

Required in Group VI. (Morse)

XXI HEATING AND VENTILATING **Lectures**

Credit two hours.

This course includes the principles of the heating of buildings by steam, hot water, and hot air. Temperature regulation, and control and ventilation are also considered together with the necessary equipment.

Prerequisite: Course XX.

Two hours a week during the second semester of the senior year.

Required in Group VI. (Morse)

XXII INDUSTRIAL MANAGEMENT **Lectures** (Elective)

Credit two hours.

This course deals with factory organization, management, and economic operation. The labor question, wage systems, welfare work, industrial training, and production problems are considered in detail.

Prerequisites: Courses XI and XII.

Two hours a week during the second semester of the senior year. (Morse)

XXIII JIGS AND FIXTURES **Drawing** (Elective)

Credit one hour.

This course consists of the design of various forms of jigs and fixtures, cutting and forming tools, and attachments which

are so widely used in present day manufacturing plants for the economic production of various kinds of machine parts.

Prerequisites: Courses XI and XII.

Three hours a week during the first semester of the senior year. (Morse)

XXIV MANUFACTURING METHODS AND PROCESSES
Lectures

Credit one hour.

This course refers to commercial practice in foundry work, forge shop methods, and machine shop, and tool room operations. It is intended to acquaint the student with the various operations in the manufacture and construction of machinery in order to enable him to make design drawings, which will conform to shop and factory requirements.

Prerequisites: Courses VII and VIII.
Math. VI.

One hour a week in the first semester of the junior year.
Required in Group VI. (Morse)

METALLURGY

Irving Allston Palmer, Professor
Charles Y. Pfoutz, Assistant Professor of Metallurgy
Walter L. Maxson, Assistant Professor of Metallurgy
Charles A. Townsend, Instructor in Metallurgy.

I ASSAYING **Lectures**

Credit one hour

This course includes a discussion of the underlying principles of fire assaying, its relation to chemistry and metallurgy, the reasons for its use, and its application to the determination of metals in ores and metallurgical products. The methods, reagents, furnaces, and apparatus used in commercial work are described. It is aimed to make the course as practical as possible.

Prerequisites: Physics I to IV, inclusive.
Geology I to IV, inclusive.
Chemistry I to X, inclusive.

Lectures one hour a week during the first or second semesters of the junior year.

Required in Groups I, III and IV. (Townsend)

II ASSAYING **Laboratory**

Credit three hours.

In this course the student is required to put into practice what he has learned in the lectures. The stock room of the laboratory has a large supply of assayed and analyzed pulp and bullion samples from various mining, milling, and smelting companies, and a given number of these samples are submitted to the students for assay. The work is continued until results are obtained closely checking those reported by the companies donating the samples. Special attention is paid to minor points in manipulation and to the attainment of speed as well as accuracy.

Prerequisite: This course may be taken only in conjunction with Course I

Laboratory nine hours a week during the first or second semesters of the junior year.

Required in Groups I, III and IV. (Townsend)

III GENERAL METALLURGY

Credit three hours.

In this course there are taken up for consideration the general principles of metallurgy; the production, uses, and prop-

erties of the more important metals; alloys and metallic compounds; ores of the common metals; fuels, refractories, furnaces, and apparatus; and a brief outline of the principal metallurgical processes.

Prerequisites: Chemistry VIII and X.
Geol. IV.
Physics III and IV.

Three hours a week during the first semester of the junior year.

Required in Groups I, III, and IV. (Palmer)

IV METALLURGY OF IRON AND STEEL Lectures

Credit two hours.

This course includes a discussion of the production statistics, uses, and properties of iron and steel; the principal ores of iron; blast furnace smelting; the manufacture of wrought iron and steel; and the various methods of founding, mechanical treatment, and heat treatment.

Prerequisites: Physics III and IV.
Geology IV.
Chemistry VIII and X.

Two hours a week during the first semester of the junior year.

Required in Groups I, III, and IV. (Pfoutz)

V METALLURGY OF LEAD Lectures

Credit three hours.

The metallurgy of lead is considered in the following order: properties of lead and its alloys and compounds; ores of lead; smelting in the ore hearth; roasting of ores, including the chemistry of the roasting process; blast furnace smelting, including construction, chemistry of the blast furnace, calculation of furnace charges, treatment of products; softening, desilverization, and refining of base bullion; Pattinson process; Parkes process; Betts process; and cupellation.

Prerequisite: Course III

Three hours a week during the second semester of the junior year.

Required in Groups I and III. (Palmer)

VI METALLURGY OF ZINC Lectures

Credit two hours.

The subject is treated in the following order: production and uses of zinc; chemical and physical properties; alloys and compounds; ores; calcination; roasting; smelting; the manufacture of retorts and condensers; retort and furnace fuels; types

of roasting and retort furnaces; refining; and an outline of the electrolytic recovery of zinc.

Prerequisite: Course III

Two hours a week during the second semester of the junior year.

Required in Groups I and III. (Maxson)

VII ORE DRESSING **Lectures**

Credit two hours.

This course is designed to give the student a general idea of the modern theory and practice of ore dressing. The underlying principles are discussed, and the application of these principles to the concentration of ores is illustrated by references to laboratory experiments and to commercial work. Emphasis is placed upon the economic side of the subject. On account of the rapid changes in ore dressing practice only the more modern milling plants are taken up for detailed examination and study.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor

Two hours a week during the first semester of the senior year.

Required in Groups I and III. (Pfoutz, Maxson)

VIII ORE DRESSING **Laboratory**

Credit one hour.

This course is designed to supplement the lectures on the subject by giving the student practice in the handling of ore dressing equipment. The first part of the course is devoted to laboratory experiments, illustrating general principles, and to the study of the construction, capacity, efficiency, and power consumption of such machines and other apparatus as are available. This work is followed by the testing of ores. Visits are made to commercial milling plants and the information thus gained incorporated in reports prepared by the student.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor

Three hours a week during the first semester of the senior year.

Required in Groups I and III.

(Pfoutz, Maxson, Townsend)

IX PYROMETRY AND HEAT TREATMENT **Laboratory**
Credit one hour.

This course is intended to supplement the lecture work of the junior year and includes high temperature measurements with optical and radiation pyrometers and rare and base metal thermocouples; standardization of couples; thermal study of metals and some of the common binary alloys; study of physical properties; mechanical testing and thermal treatment of metals.

Prerequisite: This course is intended primarily for regular members of the junior class, but others may take it with the consent of the instructor

Three hours a week during the second semester of the junior year.

Required in Group III. (Maxson)

X METALLURGY OF COPPER, GOLD, AND SILVER **Lectures**
Credit two hours.

This course includes a study of the production, uses, properties, alloys, compounds, and ores of copper, gold, and silver, and of the principal pyrometallurgical processes used in the extraction and refining of these metals. An outline of the most important hydrometallurgical processes is also included.

Prerequisite: Course III.

Two hours a week during the second semester of the senior year.

Required in Groups I and III. (Pfoutz)

XII METALLOGRAPHY **Lectures** (Elective)
Credit two hours.

This course comprises a study of the general methods of investigating the thermal and physical properties of metals; mechanical testing; thermal treatment; and defects of metals and alloys and the causes.

Prerequisite: This course is intended primarily for regular members of the junior class, but others may take it with the consent of the instructor

Two hours a week during the second semester of the junior year. (Maxson)

XIII METALLOGRAPHY **Laboratory** (Elective)
Credit one hour.

This course is intended to supplement the lectures and includes the application of the principles of every day commercial practice from the initial heating of metals and alloys for mechanical treatment to the cooling in the final heat treatment; the exam-

ination of metals and alloys under the microscope; the effect of impurities on physical properties; use of different etching media; and the photographing of sections.

Prerequisite: This course is intended primarily for regular members of the junior class, but others may take it with the consent of the instructor

Three hours a week during the second semester of the junior year. (Maxson, Townsend)

XIV HYDROMETALLURGY **Lectures** (Elective)

Credit two hours.

This course comprises a study of the principal leaching and electrolytic methods used in the extraction and refining of gold, silver, copper, lead, and zinc. Among the processes considered are the amalgamation and cyanidation of gold and silver ores, the leaching of oxidized copper ores, the roasting and leaching of zinc ores, and the various methods of electrolytic precipitation and refining.

Prerequisites: This course is intended primarily for regular members of the senior class, and for post graduate students, but others may take it with the consent of the instructor.

Two hours a week during the first semester of the senior year. (Maxson)

XV HYDROMETALLURGY **Laboratory** (Elective)

Credit one hour.

This course supplements the lectures and includes practice in the amalgamation and cyanidation of gold and silver ores, the leaching of copper and zinc ores, and electrolytic precipitation and refining.

Prerequisites: This course is intended primarily for regular members of the senior class, and for post graduate students, but others may take it with the consent of the instructor.

Three hours a week during the first semester of the senior year. (Maxson, Townsend)

XVI ORE DRESSING **Laboratory** (Elective)

Credit one hour.

This is a practical course in the concentration of low grade and complex ores. The ores are first treated on the laboratory scale by gravity and flotation concentration, all products being analyzed and a tentative flow sheet made. The ore is then treated in larger quantities, and the student is required to make any changes that are deemed advisable. The metallurgical recov-

ery based on products, and the economic recovery based on smelter contracts are figured. The grades of concentrates produced are then varied so as to obtain as high a metallurgical recovery as is consistent with economic recovery.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor

Three hours a week during the second semester of the senior year. (Pfoutz)

XVII METALLURGICAL PROBLEMS **Lectures** (Elective)

Credit one hour.

This course is designed to include not only a discussion of the more important technical metallurgical problems in connection with the extraction and refining of metals, but, in the larger sense, the economic problems, so as to include a consideration of such questions as labor, transportation, fuel supplies, location of of plants, technical education, and the organization and management of metallurgical companies.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor

One hour a week during the first semester of the senior year. (Palmer)

XVIII ORE DRESSING **Lectures**

Credit two hours.

This is a continuation of Course VII.

Prerequisites: Courses VII and VIII.

Two hours a week during the second semester of the senior year.

Required in Groups I and III. (Pfoutz, Maxson)

XIX ORE DRESSING **Laboratory**

Credit one hour.

This is a continuation of Course VIII.

Prerequisites: Courses VII and VIII.

Three hours a week during the second semester of the senior year.

Required in Groups I and III.

(Pfoutz, Maxson, Townsend)

XX HYDROMETALLURGY **Lectures** (Elective)

Credit two hours.

This is a continuation of Course XIV.

Prerequisites: Courses XIV and XV.

Two hours a week during the second semester of the senior year. (Maxson)

XXI HYDROMETALLURGY Laboratory (Elective)

Credit one hour.

This is a continuation of Course XV.

Prerequisites: Courses XIV and XV.

Three hours a week during the second semester of the senior year. (Maxson, Townsend)

METAL MINING

Lester S. Grant, Professor
James Underhill, Associate Professor
and Director of the School Mine
H. T. Flint, Fellow

Throughout the courses given in this department particular stress is laid on modern practice in the mining world. The subjects taught range from elementary work and general principles to those in which instruction is given in the detail of mining methods, in mine valuation, and in mine management. The importance of keeping in touch with the most recent developments in mining is impressed on the student by constant reference to current mining literature.

I MINERAL LAND SURVEYING **Lectures**

This course covers instruction in the methods of acquiring title to mineral lands in the United States and in foreign countries, and in surface and underground mine surveying. Special attention is given to practice in the western United States. The duties of the United States Mineral Surveyors are explained and the student is familiarized with the field methods and office practice involved in obtaining United States patent to mineral lands.

Prerequisites: C. E. I and II

One hour a week during the first semester of the sophomore year.

Required of all students. (Underhill)

II MINE AND MINERAL LAND SURVEYING **Lectures**

This is a continuation of Course I.

Prerequisite: Course I

One hour a week during the second semester of the sophomore year.

Required of all students. (Underhill)

III MINE SURVEYING **Field Work**

This course embraces practice in laying out mining claims on the ground and in surveying underground workings. The students are organized in suitable squads for efficient work in the field. The practice in surface and underground work is given at the School Mine Camp at Idaho Springs, where the mines provide a variety of problems common to mine surveying, such as shaft plumbing, adit and drift traversing.

Prerequisites: Courses I and II

Four weeks in the summer following the close of the sophomore year.

Required in Groups I and IV. (Underhill)

IV MINING LABORATORY (Elective)

Credit one hour.

The work in this course is performed at the School Mine Camp at Idaho Springs. The Camp is equipped with a forge and tools for blacksmithing, timbering, track laying, piping, and repair work: also drill steel, machine drills, mine cars, and other apparatus used in the underground work. The students work in squads of three or four and perform all of the usual duties involved in the driving of a tunnel, such as track laying, timbering, drilling by hand and with machine drills, blasting, mucking, and tramming. Under the instruction of a practical miner, the students are taught to temper and sharpen their own steel to suit the varying conditions of ground and for the different makes of drills. Opportunity is afforded students to do extra work investigating the efficiency and power consumption of different makes of drills and the relative advantages of various brands of high explosives.

Two weeks in the summer following the close of the sophomore year. (Underhill)

V MINE MAPPING DRAWING

Credit one hour.

This is a drafting room course wherein the student is required to perform all office work necessary in connection with the surveys made in Course III, Mine Surveying Field Work, including the preparation of plats, field notes, and reports required by Land Office Directors and Surveyors General, and the drawing of accurate maps of all mine surveys and water rights.

Prerequisite: Course III

Three hours a week during the first semester of the junior year.

Required in Groups I and IV. (Underhill)

VI PRINCIPLES OF MINING Lectures

Credit two hours.

This course is introductory to the succeeding metal mining courses. The general principles of exploitation of mineral deposits are presented; also an elementary discussion of the mining laws and regulations of the United States and foreign countries.

Prerequisites: M. M. I and II.
Geol. I, II, III, and IV.

Two hours a week during the first semester of the junior year.

Required in Groups I and III. (Underhill)

VII PRINCIPLES OF MINING Lectures

Credit two hours.

This is a continuation of Course VI.

Prerequisites: M. M. I, II, and VI

Two hours a week during the second semester of the junior year.

Required in Groups I and III. (Underhill)

VIII ACCOUNTING Lectures

Credit two hours.

This course covers the fundamental principles of bookkeeping. The student is taught how to use the various books, records, and blanks involved in standard systems of accounting. Special attention is given to systems employed in dealing with the accounts of mining corporations.

Prerequisite: This course is intended primarily for regular members of the junior class, but others may take it with the consent of the instructor

Two hours a week during the first semester of the junior year.

Required in Group I. (Grant)

IX MINING CORPORATIONS Lectures

Credit one hour.

This course covers the essentials of corporation laws involved in the organization and operation of industrial corporations, particularly those engaged in mining.

Prerequisite: This course is intended primarily for regular members of the junior class, but others may take it with the consent of the instructor

One hour a week during the first semester of the junior year.

Required in Group I. (Underhill)

X PLACER MINING Lectures

Credit two hours.

The theory and practice involved in the recovery of precious metals from alluvial deposits is covered in this course. The various types of placers and the proper methods of working them are explained, as well as the equipment employed in mining the deposits. Sampling and examination of placers, hydraulicking and dredging are covered. The construction of

reservoirs, ditches, and pipe lines, including the principles of hydraulics involved therein, is discussed.

Prerequisites: Geol. I, II, III, and IV.

Two hours a week during the second semester of the junior year.

Required in Group I. (Grant)

XI METAL MINING **Lectures**

Credit two hours.

The various methods of mining are dealt with in this course. Stoping of ore in both narrow and wide veins and in massive deposits, by the various modern systems is thoroughly discussed and the several stages of the operation explained. The course concludes with lectures on the most important metal producing districts and the best known mines of the world. Students are required to prepare reports on mines or districts, as assigned by the instructor.

Prerequisites: Course VI and VII.

Two hours a week during the first semester of the senior year.

Required in Group I. (Grant)

XII METAL MINING **Lectures**

Credit two hours.

Details of mining are covered in this course, which includes a study of mining machinery. Breaking of rock, underground and surface haulage, and hoisting, are discussed, and the present day machinery that is employed in these operations is explained, a liberal use of manufacturers catalogs being made in connection with this work. Students are required to select, from catalogs, suitable machinery for problems assigned to them.

Prerequisites: Course VI and VII.

Two hours a week during the second semester of the senior year.

Required in Group I. (Underhill)

XIII MINE VALUATION **Lectures**

Credit two hours.

This course includes a detailed discussion of the methods of mine sampling. The measurement of ore bodies and the estimating of tonnage are described. The recording of assays, tabulating calculations, and compiling data in comprehensive form, are explained. Suggestions are given for the arrangement and presentation of the essential information required in mine reports.

Prerequisites: Courses I to VII, inclusive

Two hours a week during the first semester of the senior year.

Required in Groups I and IV. (Underhill)

XIV MINE MANAGEMENT AND ECONOMICS Lectures

Credit two hours.

Commencing with a brief review of the fundamental principles of political economy, this course then covers the subject of investments, with special reference to mining. The different classes of corporate securities are described, and the factors which influence the value of mining securities are discussed. The latter part of the course covers the subject of mine management, and includes a discussion of the general principles of management as well as the various activities and duties of a mine manager.

Prerequisite: This course is for regular members of the senior class and for post graduate students.

Two hours a week during the second semester of the senior year.

Required in Group I. (Grant)

XVI PRACTICAL ASTRONOMY Lectures

Credit one hour.

This course covers a study of the celestial sphere including sun, moon, earth, and planets; the constellations; the measurement of time; problems necessitating familiarity with and use of the nautical almanac, and such problems of practical astronomy as may be solved by the surveyor with a surveyor's transit.

Prerequisites: Courses I and II, C. E. I and II

This course may be taken only with the consent of the instructor.

One hour a week during the second semester of the junior year.

Required in Group VIII. (Underhill)

MILITARY SCIENCE AND TACTICS

Reserve Officers' Training Corps

Capt. Walter E. Lorence, Corps of Engineers, U. S. A., Professor
Edward W. Wiegman, U. S. A., Instructor

The work of this department is arranged to give the student a fundamental training in military science and tactics, an understanding of engineering from the military standpoint, and experience as a cadet officer and non-commissioned officer. This work, with the other technical courses a student must complete to obtain a degree, qualifies the graduate for a commission as Second Lieutenant of Engineers in the Officers' Reserve Corps.

I PRACTICE OF MILITARY SCIENCE AND TACTICS **Field Work**

In this course the student is given the military drill and practical field work necessary in the study of military organization, courtesy and discipline, infantry drill, close and extended order, including school of the soldier, squad, platoon, and company, ceremonies and marching, care and handling of arms and equipment, small arms firing, including gallery and range firing, interior guard duty and minor tactics.

Two hours a week during the first semester of the freshman year.

Required of all students. (Wiegman)

II THEORY OF MILITARY SCIENCE AND TACTICS **Lectures**

This course consists of lectures and recitations on the subjects listed under Course I.

One hour a week during the first semester of the freshman year.

Required of all students. (Wiegman)

III PRACTICE OF MILITARY SCIENCE AND TACTICS **Field Work**

This course is a continuation of Course I, with the addition of practical work in first aid, signaling, cordage, rigging, and hasty bridging.

Two hours a week during the second semester of the freshman year.

Required of all students. (Wiegman)

IV THEORY OF MILITARY SCIENCE AND TACTICS Lectures

This course is a continuation of Course II.

Prerequisites: Courses I and II

One hour a week during the second semester of the freshman year.

Required of all students. (Wiegman)

V PRACTICE OF MILITARY SCIENCE AND TACTICS Field Work

This course consists of close and extended order drill in the school of the soldier, squad, platoon, and company, ceremonies and marching, minor tactics, and gallery practice.

Prerequisites: Courses III and IV.

Two hours a week during the first semester of the sophomore year.

Required of all students. (Wiegman)

VI THEORY OF MILITARY SCIENCE AND TACTICS Lectures

This course consists of lectures and recitations on the subject listed under Course V, and in addition lectures on the care of troops, camp sanitation, gas warfare, and ponton equipment and construction.

Prerequisites: Courses III and IV

One hour a week during the first semester of the sophomore year.

Required of all students. (Wiegman)

VII PRACTICE OF MILITARY SCIENCE AND TACTICS Field Work

This course is a continuation of Course V, with the addition of practical work in military map making and sketching.

Prerequisites: Courses V and VI

Two hours a week during the second semester of the sophomore year.

Required of all students. (Wiegman)

VIII THEORY OF MILITARY SCIENCE AND TACTICS Lectures

This course is a continuation of Course VI, and in addition lectures on ordnance and field fortification.

Prerequisites: Courses V and VI

One hour a week during the second semester of the sophomore year.

Required of all students. (Wiegman)

IX PRACTICE OF MILITARY SCIENCE AND TACTICS Field Work (Elective)

Credit one-half hour.

In this course the student is trained in the duties consistent with the rank of non-commissioned officers, in the practical work of close and extended order drill, guard duty, minor tactics, and engineer work.

Prerequisite: This course may be taken only with the consent of the instructor

One hour a week during the first semester of the junior year. (Lorence)

X THEORY OF MILITARY SCIENCE AND TACTICS Lectures (Elective)

Credit two hours.

Advanced study by lectures and discussion of the subjects listed under Course I and V, and of the following: Civil law, military history and campaigns, map reading, army administration, supply methods in garrison and field, and mess management.

Prerequisite: This course may be taken only with the consent of the instructor

Two hours a week during the first semester of the junior year. (Lorence)

XI PRACTICE OF MILITARY SCIENCE AND TACTICS Field Work (Elective)

Credit one-half hour.

This course is a continuation of Course IX.

Prerequisite: This course may be taken only with the consent of the instructor.

One hour a week during the second semester of the junior year. (Lorence)

XII THEORY OF MILITARY SCIENCE AND TACTICS Lectures (Elective)

Credit two hours.

This course is a continuation of Course X, and of the following: hippology, including care of animals in garrison and field, stable management and exercise, simple injuries, ailments and remedies, military bridges, including improvised, and standardized, fixed and floating types, military roads, including location, types, construction, and maintenance, railways for military purposes, including considerations affecting location, character, capacity, construction, and operations.

Prerequisite: This course may be taken only with the consent of the instructor

Two hours a week during the second semester of the junior year. (Lorence)

XIII PRACTICE OF MILITARY SCIENCE AND TACTICS Field Work (Elective)

Credit one-half hour.

In this course the student is trained in the duties consistent with the rank of officers in the practical work of close and extended drill, guard duty, minor tactics, and engineer work.

Prerequisite: This course may be taken only with the consent of the instructor

One hour a week during the first semester of the senior year. (Lorence)

XIV THEORY OF MILITARY SCIENCE AND TACTICS Lectures (Elective)

Credit one hour.

This course is a continuation of Course XII, with the addition of the following subjects: discipline, leadership, military law, international law, military policy, and mechanical ordnance and equipment.

Prerequisite: This course may be taken only with the consent of the instructor.

One hour a week during the first semester of the senior year. (Lorence)

XV PRACTICE OF MILITARY SCIENCE AND TACTICS Field Work (Elective)

Credit one-half hour.

This course is a continuation of Course XIII.

Prerequisite: This course may be taken only with the consent of the instructor

One hour a week during the second semester of the senior year. (Lorence)

XVI THEORY OF MILITARY SCIENCE AND TACTICS Lectures (Elective)

Credit one hour.

This course is a continuation of Course XIV, with the addition of the following subjects: the organization and administration of engineering projects, and the use of engineer troops in war.

Prerequisite: This course may be taken only with the consent of the instructor

One hour a week during the second semester of the senior year. (Lorence)

XVII PRACTICE OF MILITARY SCIENCE AND TACTICS
Field Work (Elective)

Credit one hour.

This course consists of practical problems in engineer reconnaissance, military sketching, map reproduction, and photography and map problems involving security, combat, reconnaissance, and the characteristic tactics of various arms.

Prerequisite: This course may be taken only with the consent of the instructor

Three hours a week during the first semester of the senior year. (Lorence)

XVIII PRACTICE OF MILITARY SCIENCE AND TACTICS
Field Work (Elective)

Credit one hour.

This course consists of practical problems in general construction applicable in war and peace including plans and layouts for camps and cantonments, barracks, quarters, hospitals, storehouses, wharves, docks, railway terminals and miscellaneous structures, also problems in fortifications, permanent, semi-permanent and temporary works, including organization of the ground, trenches and trench layouts, gun emplacements, shelters, obstacles, camouflage, demolitions, explosives, and mine warfare.

Prerequisite: This course may be taken only with the consent of the instructor

Three hours a week during the second semester of the senior year. (Lorence)

MINING LAW

Joseph S. Jaffa, Professor

I MINING LAW (Elective)

Credit one hour.

a. Status of the law previous to the discovery of gold in California in 1848.
Organization of mining districts in California and other states; Federal legislation; subsequent state legislation.

b. Lode claims under the act of 1872.
Valuable mineral deposits; surveyed and unsurveyed land; vein or lode; in place; apex; mining claims and location.

c. Important requisites of a valid lode location.
Discovery and location; sinking of shaft; posting of notice and recording; size of location; apex within the location; end lines; side lines; side-end lines; overlapping.

d. Extralateral rights under the act of 1872.
Broad lodes; vein entering and leaving on same side line; vein crossing both parallel side lines; vein crossing end lines and side lines; miscellaneous cases.

e. Secondary veins.

f. Discussion and interpretation of Federal and State Courts of Sec. 2336 U. S. Rev. Statutes as to "the Space of Intersection".

g. Placer claims:
What is locatable as placer; acts of location; known lodes within placers.

h. Tunnel sites.
Location; location of blind veins in tunnel sites; rights of way through prior patented or unpatented claims.

i. Mill sites.

j. Annual labor or assessment work.

k. Abandonment, forfeiture, and relocation.

l. Patent.

Prerequisite: This course is intended primarily for regular members of the senior class and for post graduate students, but others may take it with the consent of the instructor

One hour a week during the first semester of the senior year.

(Jaffa)

PETROLEUM ENGINEERING

W. K. Kirby, Professor

The object of this work is to give the student a thorough, practical knowledge so that he may enter either the production, the transportation, or the refining division of the petroleum industry. The latest methods and apparatus used in all branches of the petroleum industry are considered.

I OIL WELL DRILLING Lectures

Credit two hours.

This course outlines the method of drilling oil and gas wells. It comprises a study of the standard, rotary, combination, and hydraulic circulating systems of drilling. A study is made of drilling rigs, tools, casing and casing tools, fishing tools and method of use, locating and spacing wells, logs of wells, and the use of electricity in oil well drilling. The problem of the exclusion of water in oil fields, cementing of wells, and the cost of the different systems of drilling are also considered. A short trip to the Wyoming oil field is included in this course.

Prerequisites: Math. V and VI.
Chem. I to X.
Geology I to IV.
Physics I to IV.
Mech. Eng. V to VIII.

Two hours a week during the first semester of the junior year.

Required in Group V. (Kirby)

II GATHERING SYSTEMS Lectures

Credit one hour.

This course includes lectures on the method of gathering, measuring, and storing of crude oil. A study is made of the design of storage tanks, concrete oil reservoirs, pumps, gathering systems, and the layout of tank farms. The evaporation of oil in storage, and fire protection systems are also discussed. Drawings and trade catalogs are consulted for the purpose of acquainting the student with the practical applications.

Prerequisites: Math. V and VI.
Physics I to IV.
Chem. I to X.
Mech. Eng. V to VIII.
Geology I to IV.

One hour a week during the first semester of the junior year.

Required in Group V. (Kirby)

III OIL PRODUCTION Lectures

Credit two hours.

This course follows Course I, and is devoted to a study of the process of bringing the oil and gas to the surface. It comprises a study of the different methods of pumping and cleaning wells, separating the oil and gas, and methods of dehydrating the oil. Study is given to the management of oil leases in order to acquaint the student with the best methods of obtaining efficient and maximum production. The methods of obtaining oil and gas lands, and the valuation of oil producing properties are also included. A short trip to the Wyoming oil field is taken in order to acquaint the student with the practical conditions of producing properties.

Prerequisites: Courses I and II.

Two hours a week during the second semester of the junior year.

Required in Group V. (Kirby)

IV TRANSPORTATION Lectures

Credit one hour.

In this course instruction is given in the flow of light and heavy oil in pipe lines, and the marine transport of petroleum. The work covers the designing, estimating, and operation of complete light and heavy oil pumping systems, pumping stations, steam and hot air oil heating stations, oil heaters, and other auxiliary apparatus. A study is also made of railway tank cars, tank barges, and tank steamers. Designs, blueprints, catalogs, and specifications are used in order to acquaint the student with the practical apparatus in current use. The course includes calculations of the cost of transporting oil for the respective systems.

Prerequisites: Courses I and II.

One hour a week during the second semester of the junior year.

Required in Group V. (Kirby)

V PETROLEUM REFINING **Lectures**

Credit three hours.

This course includes a discussion of all the products produced from petroleum, their specifications, testing, and usage. Lectures are given on refining systems, the designing, estimating, and operation of skimming plants, topping plants, and complete refineries for paraffin, asphalt, and mixed base oils. A study is made of treating, lubricating, asphalt, coke, and wax plants; conventional stills, pipe stills, vapor towers, heat exchangers, agitators, dephlegmators, coolers, condensers, still settings, look boxes, and other auxiliary apparatus. Cracking plant operation and design are also included in the course. Designs, blueprints, catalogs, and specifications are freely used in order that the student may familiarize himself with practical equipment. The relative cost of refining under each system is considered. Visits to refineries are required.

Prerequisites: Courses I to IV.
Chemistry XIX, XX, XXI, and XXII.

Three hours a week during the first semester of the senior year.

Required in Group V. (Kirby)

VI DISTRIBUTION OF PETROLEUM PRODUCTS **Lectures**

Credit one hour.

This course comprises lectures on the general distribution of petroleum in the crude state, and the methods of distribution and selling of the refined petroleum products. The designs of distributing systems, service stations, and tank wagons are included, as well as the rules and regulations for the distribution and storing of refined petroleum products.

Prerequisites: Courses I to IV.

One hour a week during the first semester of the senior year.

Required in Group V. (Kirby)

VII CASING HEAD GASOLINE PLANTS **Lectures**

Credit three hours.

This course consists of the designing, estimating, and operation of casing head gasoline plants. Lectures are also given on absorption and compression gasoline plants. Complete flow sheets are developed for both classes of plants; a study is made of absorption towers, compressors, steam stills, pipe stills, interchangers, cooling towers, condensers, coolers, blending towers, tanks, and other auxiliary apparatus. Blueprints, designs, and layouts of plants are consulted in order that the students may

become acquainted with the apparatus used in current practice. The cost of producing casing head gasoline is also considered, A visit to the field is included.

Prerequisites: Courses V and VI.

Three hours a week during the second semester of the senior year.

Required in Group V. (Kirby)

VIII ORGANIZATION OF OIL COMPANIES Lectures

Credit one hour.

This course comprises lectures on the organization, management, size, scope, general statistics, and the necessary elements of a successful oil or gas company. A discussion of the oil market, and of the future oil supply is also included.

Prerequisites: Courses V and VI.

One hour a week during the second semester of the senior year.

Required in Group V. (Kirby)

PHYSICS

A. E. Bellis, Professor of Physics
Carey P. Butcher, Fellow

The courses in Physics have been designed to meet the needs of engineering students, and, to this end, special emphasis is laid on those subjects of importance to the students of this school. Neither the theoretical nor the practical side is neglected, as the aim in this important science is to ground the student thoroughly in the fundamentals. The laboratory is exceptionally well equipped for individual experimentation.

I GENERAL PHYSICS **Lectures and Recitations**

This course includes mechanics, sound, and heat. The lectures are illustrated by class experiments. Recitations are supplemented by a substantial course in practical and theoretical problems. All important equations are developed and discussed. Calculus is used frequently.

Prerequisites: Mathematics I to IV, and registration in Mathematics V

Four hours a week during the first semester of the sophomore year.

Required of all students. (Bellis)

II PHYSICAL MEASUREMENTS **Laboratory**

This course accompanies Course I.

The experiments are selected to meet the requirements of engineering students and include work in mechanics, sound, and heat. Permanent note books are required and must be well kept. A high grade of work is expected. In this course a student becomes familiar with the usual instruments of precision and verifies the important laws of physics.

Prerequisite: Registration in Course I

Six hours a week during the first semester of the sophomore year.

Required of all students. (Bellis, Little)

III GENERAL PHYSICS **Lectures and Recitations**

Magnetism, electricity, and light.

This course is a continuation of Course I. The lectures include class demonstrations in many interesting and useful phe-

nomena as well as the development and discussion of useful formulae, to be applied to problems to be solved. As in Course I, calculus is used frequently.

Prerequisites: Physics I and II and registration in Mathematics VI

Four hours a week during the second semester of the sophomore year.

Required of all students. (Bellis)

IV PHYSICAL MEASUREMENTS Laboratory

This course is a continuation of Course II, and includes work in magnetism, electricity, and light. The laboratory is exceptionally well equipped with modern apparatus in sufficient amount for individual experimentation.

Prerequisite: Registration in Course III

Six hours a week during the second semester of the sophomore year.

Required of all students. (Bellis, Little)

V ADVANCED HEAT Lectures (Elective)

Credit one hour.

This course is designed to be an advanced course in heat and consists of the study of modern methods of heat measurements, including high temperature measurements, as well as calorimetry.

Prerequisites: Physics I and II

One hour a week during the first semester of the junior year. (Bellis)

VI PHYSICS PROBLEMS (Elective)

Credit one hour.

This course is for the purpose of giving more attention to problems than is possible in Courses I and III. Practical problems in all branches of physics are taken up, studied, and solved.

Prerequisites: Physics I, II, III, and IV.

One hour a week during the second semester of the junior year. (Bellis)

VII ELECTRICAL MEASUREMENTS Laboratory (Elective)

Credit one hour.

The course in electrical measurements consists of the laboratory study of modern methods of measuring resistance, internal resistance of cells, resistance of electrolytes, calibration of bridge wires, measurements of current, measurement of E.M.F., calibration of voltmeters, ammeters, and wattmeters; also methods for the location of faults in telephone circuits.

Prerequisites: Physics I and III

Three hours a week during the first semester of the junior year. (Bellis)

VIII ADVANCED ELECTRICAL MEASUREMENTS Laboratory (Elective)

Credit one hour.

This is a continuation of Course VI and takes up the study of capacity, inductance, and magnetism, also the absolute measuring of laboratory standards. The laboratory is well equipped with modern apparatus for this work.

Prerequisites: Physics I and III

Three hours a week during the second semester of the junior year. (Bellis)

IX ADVANCED LIGHT Laboratory (Elective)

Credit one hour.

This course consists of the study of spectrum analysis, measurement of wave lengths, and index of refraction of different forms of optical glass. This is a practical laboratory course using a high grade of apparatus.

Prerequisites: Physics I and III

Three hours a week during the second semester of the senior year. (Bellis)

SPANISH

C. Desmartin, Instructor in Modern Languages

I SPANISH ELEMENTARY (Elective)

Credit two hours.

Conversation. The only method by which a modern language can be learned is by talking. This method is rigorously pursued.

Pronunciation. The correct pronunciation of a modern language is vital and can be acquired only by constant practice in conversation.

Grammar. Sufficient grammar is taught to enable the student to use the ordinary forms of the language correctly.

Prerequisite: This course is intended primarily for juniors, but others may take it with the consent of the instructor.

Two hours a week during the first semester of the junior year. (Desmartin)

II SPANISH ELEMENTARY (Elective)

Credit two hours.

Conversation. This is continued as in Course I.

Grammar. The conjugation of the regular verbs and of the frequently used irregular verbs is studied and applied in oral and written exercises.

Correspondence. Social and commercial letters are composed and translated from English into Spanish, and from Spanish into English.

Prerequisite: Course I.

Two hours a week during the second semester of the junior year. (Desmartin)

III SPANISH ADVANCED (Elective)

Credit two hours.

Conversation. Conversation is conducted on subjects of a mining and technical nature.

Grammar. Special attention is given to the use of tenses and moods, especially to the subjunctive tenses, which are commonly used in Spanish and which do not always correspond to similar tenses in English.

Prerequisite: Course II

Two hours a week during the first semester of the senior year. (Desmartin)

IV SPANISH ADVANCED (Elective)

Credit two hours.

This is a continuation of Course III.

Prerequisite: Course III

Two hours a week during the second semester of the senior year. (Desmartin)

On the completion of Course IV any student of ordinary ability should be able to converse in Spanish with a fair degree of fluency, write a correct letter in Spanish, and translate commercial correspondence or technical literature from Spanish into English.

STANDARD TEXT AND REFERENCE BOOKS

METAL MINING

Underhill—Mineral Land Surveying
General Land Office—Manual of Instructions for the Survey of Mineral Lands of the United States
General Land Office—Standard Field Tables
Trumbull—Manual of Underground Surveying
Durham—Mine Surveying
Morrison—Mining Rights
Charlton—American Mine Accounting
Lough—Corporation Finance
Wilson—Hydraulic and Placer Mining
Longridge—Hydraulic Mining
Hoover—Principles of Mining
Young—Elements of Mining
Sanders—Mine Timbering
Brinsmade—Mining Without Timbers
Brunton and Davis—Modern Tunneling
Crane—Ore Mining Methods
Peele—Mining Engineers Handbook
Gillette—Handbook of Rock Excavation
Rickard—Sampling and Estimation of Ore in a Mine
Herzig—Mine Sampling and Valuing
Gunther—Examination of Prospects
Babson—Business Barometers
Finlay—Cost of Mining
McGarraugh—Mine Bookkeeping
McGrath—Mine Accounting

METALLURGY

Hofman—General Metallurgy
Richards—Metallurgical Calculations
Gowland—The Metallurgy of the Non-Ferrous Metals
Fulton—Manual of Fire Assaying
Stoughton—Metallurgy of Iron and Steel
Johnson—Blast Furnace Construction in America
Johnson—The Principles, Operation, and Products of the Blast Furnace
Campbell—Manufacture and Properties of Iron and Steel
Harbord and Hall—The Metallurgy of Steel
Turner—The Metallurgy of Iron
Hofman—Metallurgy of Lead

Ingalls—Metallurgy of Zinc and Cadmium
Hofman—Metallurgy of Copper
Clennell—The Cyanide Handbook
Rose—The Metallurgy of Gold
Julian and Smart—Cyaniding Gold and Silver Ores
Richards—Textbook of Ore Dressing
Wiard—Theory and Practice of Ore Dressing
McGraw—The Flotation Process
Rickard and Ralston—Flotation
Hoover—Concentrating Ores by Flotation
Sauveur—The Metallography and Heat Treatment of Iron and Steel
Bullens—Steel and Its Heat Treatment
Gulliver—Metallic Alloys
Williams—Principles of Metallography
Stansfield—The Electric Furnace
Rodenhauser and Shoenawa—The Electric Furnace in the Iron and Steel Industry

CHEMISTRY

Smith—Quantitative Analysis
Botkin—Quantitative Determinations
Olsen—Quantitative Chemical Analysis
Treadwell and Hall—Analytical Chemistry, Vol. II
Low—Technical Methods of Ore Analysis
Scott—Standard Methods of Chemical Analysis
Lord and Demorest—Metallurgical Analysis
Blair—Analysis of Iron and Steel
Johnson—Chemical Analysis of Special Steels and Steel Making Alloys
Moore—Outlines of Organic Chemistry
Cohen—Theoretical Organic Chemistry
Sadtler—Industrial Organic Chemistry
Thorpe—Outlines of Industrial Chemistry
Bacon and Hamor—The American Petroleum Industry
Redwood—Treatise on Petroleum
Southerland—Petroleum Industry
Gill—Oil Analysis
Stillman—Examination of Lubricating Oils
Mueller and Holde—Examination of Hydrocarbon Oils
Tagliabue—Petroleum Manual
Ostwald—Foundations of Analytical Chemistry; the Principles of Organic Chemistry
Kansas City Testing Laboratory—Bulletin 14
Botkin—Notes on Analysis of Oil Shale

Lunge—Technical Methods of Chemical Analysis, Vol. I
Bulletins 125, 151, 176 of the United States Bureau of Mines
U. S. Geological Survey—Bulletin 641 F

CIVIL ENGINEERING

Breed and Hosmer—Plane Surveying
Wilson—Topographic Surveying
Searles—Field Engineering
Boyd—Strength of Materials
Greene—Structural Mechanics
Merriman—Mechanics of Materials
Martens—Handbook of Testing Materials
Daugherty—Hydraulics
Hughes and Safford—Hydraulics
Hoskins—Hydraulics
Church—Hydraulics
Johnson, Bryan, and Turneaure—Framed Structures
Babbitt—Sewerage
King—Handbook on Hydraulics
Williams and Hazen—Hydraulic Tables
Ketchum—Steel Mill Buildings
Marburg—Framed Structures and Girders
Jacoby—Structural Details
Ketchum—The Design of Mines Structures
Spofford—Theory of Structures
Ketchum—The Design of Highway Bridges
Blanchard—Highway Engineering
Baker—Treatise on Masonry
Baker—Treatise on Roads and Pavements
Harger and Bonney—Handbook for Highway Engineers
Mead—Water Power Engineering
Mead—Hydrology
Turneaure and Maurer—Principles of Reinforced Concrete Construction
Hool and Johnson—Concrete Engineers' Handbook
Taylor and Thompson—Concrete—Plain and Reinforced
Johnson-Smith—Surveying
Pence and Ketchum—Surveying Manual

DESCRIPTIVE GEOMETRY

O'Byrne—Descriptive Geometry
French—Engineering Drawing

MATHEMATICS

Young and Morgan—Elementary Mathematical Analysis
Webber and Plant—Introductory Mathematical Analysis

Karpinski, Benedict and Calhoun—Unified Mathematics
Walton—Treatise on Spherical Trigonometry
Burnside and Panton—Theory of Equations
Briot and Bouquet's—Elements of Analytical Geometry
Love—Differential and Integral Calculus
Granville—Differential and Integral Calculus
Phillips—Differential and Integral Calculus
Wilson—Advanced Calculus
Poorman—Applied Mechanics
Maurer—Technical Mechanics
Fuller and Johnson—Applied Mechanics
Ziwet—Theoretical Mechanics

GEOLOGY

Cleland—Geology, Physical and Historical
Chamberlin and Salisbury—College Geology
Pirsson and Schuchert—Historical Geology, Part II
Chamberlin and Salisbury—Geology, Vols. I, II, III
Grabau—Principles of Stratigraphy
Ford—Dana's Manual of Mineralogy
Dana—System of Mineralogy
Butler—Mineralogy, Blowpipe Analysis, and Crystallography
Lewis—Determinative Mineralogy
Leith—Structural Geology
Geikie—Structural and Field Geology
Tolman—Graphical Solution of Fault Problems
Lahee—Field Geology
Hayes—Handbook for Field Geologists
Farrel and Moses—Practical Field Geology
Kemp—Handbook of Rocks
Luquer—Minerals in Rock Sections
Weinschenk—Clark—Petrographic Methods
Shimer—An Introduction to the Study of Fossils
Grabau and Shimer—Index Fossils of North America
Lindgren—Mineral Deposits
Emmons—Principles of Economic Geology
Ries—Economic Geology
Gunther—Examination of Prospects
Hager—Practical Oil Geology
Engler and Hoefer—Das Erdol
Johnson and Huntley—Oil and Gas Production
Bacon and Hamor—The American Petroleum Industry
Thomson—Oil Field Development
McLaughlin—Oil Land Development and Valuation
Emmons—Geology of Petroleum
Finch—Maps and Sketch Mapping

Hinks—Maps and Survey
Ellis—Study of Geological Maps

PETROLEUM ENGINEERING

Hamor and Padgett—The Examination of Petroleum
McLaughlin—Oil Land Development and Valuation
Mueller and Holde—The Examination of Hydrocarbon Oils
Redwood—Treatise on Petroleum
Bacon and Hamor—The American Petroleum Industry
Kansas City Testing Laboratory Bulletin No. 15
Westcott—Handbook of Natural Gas
Tinkler and Challenger—The Chemistry of Petroleum
Paine and Stroud—Oil Production Methods
Thompson—Oil Field Development
Suman—Petroleum Production Methods
Johnson and Huntley—Oil and Gas Production
U. S. Bureau of Mines—Publications
U. S. Geological Survey—Publications

ELECTRICAL ENGINEERING

Gray—Principles and Practice of Electrical Engineering
Langsdorf—Principles of Direct Current Machines
Franklin and Esty—Elements of Electrical Engineering, Direct Currents
Morse—Storage Batteries
Lyndon—Storage Battery Engineering
Crocker and Arendt—Electric Motors
Sever and Townsend—Laboratory and Factory Tests in Electrical Engineering
Swenson and Frankenfield—Testing of Electromagnetic Machinery, Vols. I and II
Karapetoff—Experimental Electrical Engineering, Vols. I and II
Lawrence—Principles of Alternating Current Machinery
Bailey—The Induction Motor
Franklin and Esty—Elements of Electrical Engineering, Alternating Currents
Jansky—Electrical Meters
Miller—American Telephone Practice
Duncan and Penman—Electrical Equipment of Collieries
Patchell—Applications of Electric Power in Mines and Heavy Industries
Davies—Foundations and Machinery Fixing
Illuminating Engineering Society — Illuminating Engineering Practice
Koester—Hydroelectric Developments and Engineering

Weingreen—Electric Power Plant Engineering
Rosenthal—Transmission Calculations
Lundquist—Transmission Line Construction
Coombs—Pole and Tower Lines
Still—Overhead Electric Power Transmission
Wright—Electric Furnaces and their Industial Applications
Croft—American Electricians' Handbook
Croft—The Standard Handbook for Electrical Engineers

MECHANICAL ENGINEERING

Kimball and Barr—Elements of Machine Design
Leutwiler—Machine Design
Nachman—Elements of Machine Design
Smith and Marks—Machine Design
Dent and Harper—Kinematics of Machinery
Keown—Mechanism
Schwamb, Merrill, and James—Elements of Mechanism
Hirshfeld and Ulbricht—Steam Power
Hirshfeld and Barnard—Elements of Heat Power Engineering
Dalby—The Balancing of Engines
Furman—Valves and Valve Gears
James and Dole—Mechanism of Steam Engines
Gebhardt—Steam Power Plant Engineering
Fernald and Orrok—Engineering of Power Plants
Harding and Willard—Mechanical Equipment of Buildings
Goodenough—Principles of Thermodynamics
Lucke—Engineering Thermodynamics
Moyer, Calderwood, and Potter—Elements of Engineering Thermodynamics
Hoffman—Heating and Ventilating
Peele—Compressed Air Plant
Simons—Compressed Air
DeLaval—Centrifugal Pumping Machinery
Greene—Pumping Machinery
Streeter—Internal Combustion Engines
Moyer—Power Plant Testing
Kent—Mechanical Engineers' Pocket Book
Marks—Mechanical Engineers' Handbook
Technical Journals and Magazines
Catalogs of Mechanical Equipment

INSPECTION TRIPS

The same importance is attached to the inspection trips as to class room and laboratory work. Grades are given on reports submitted and satisfactory results are required for graduation.

METALLURGICAL TRIPS The study of various metallurgical processes and plants may be prosecuted with great benefit in Colorado. Beginning with the junior year and continuing throughout the senior year, inspection trips are taken for the purpose of supplementing the laboratory work and for illustrating the lecture courses. A written report on each trip is turned in for correction and criticism.

During the junior and senior years the following plants are visited:

The Arkansas Valley plant of the American Smelting and Refining Company, for a study of the metallurgy of lead. The Minnequa plant of the Colorado Fuel and Iron Company at Pueblo, for a study of the manufacture of iron and steel and of the working up of the product into commercial forms. The zinc plant of the American Smelting and Refining Company at Pueblo, for the study of the metallurgy of zinc. The Independence and Vindicator Mills at Victor. The Golden Cycle Mining and Reduction Company Plant at Colorado Springs.

MINING TRIPS During the junior and senior years, the students are taken to well known Colorado mining districts, as well as to adjacent states, for the inspection of actual mining operations. These trips are arranged in such order as to introduce different interesting features and, at the same time, to emphasize definite portions of the classroom instruction. Attention is paid to surface plants, underground equipment, mining systems, and to all the regular operations, both above and below ground. Lectures precede these trips to explain their objects, the particular properties to be visited, and the operations to be witnessed.

AVAILABLE MINING, METALLURGY, ENGINEERING, AND GEOLOGICAL TRIPS

COLORADO.

PORTLAND.

Metallurgy.

Colorado Portland Cement Company: crushing and fine grinding of raw material and clinker.

CANON CITY.

Metallurgy.

Empire Zinc Company: wet and magnetic separation of zinc ores and magnetic treatment of Wilfley table middlings; experimental plant with magnetizing roaster, magnetic separators, dry and electrostatic separators, and flotation installation.

Geology.

A study of the Mesozoic sedimentary formations that are upturned in fine hog backs in a great semicircle around the Canon City basin.

LEADVILLE.

Metallurgy.

Arkansas Valley Plant of the A. S. and R. Company: lead smelting; Dwight-Lloyd roasting; and blast furnace treatment of silver-lead ores.

Yak Mill: concentration of complex zinc lead sulphide ores.

Western Zinc Oxide Co.: Wetherill grate process for the production of zinc oxide.

Mining.

The students are taken into the Yak Tunnel, through the several mines connected therewith, and are finally hoisted to the surface of Breece Hill through the shaft of the Little Jonny mine. The Moyer, Tucson, and other mines are also visited. Excellent opportunity is afforded for studying the two distinctive kinds of ore bodies for which this district is noted, and to learn, by observation, how these dissimilar ore bodies are attacked and their contents successfully extracted. Interest attaches to the unusual complexity of the ores, which contain gold, silver, and most of the base metal sulphides, oxides, and carbonates.

Engineering.

Arkansas Valley Plant, A. S. and R. Company: steam power plant; capacity 1,500 h.p.; condensing Corliss engines belted to Connersville blowers; return tubular boilers equipped with underfeed stokers.

Colorado Power Company: steam power plant; Curtis turbines, direct connected to 3-phase, 6,600 volt,

60 cycle alternators; current stepped up to 100,000 volts for long distance transmission over steel tower line; small and moderate sized units; Alberger surface condensers with independent dry vacuum pump and centrifugal circulating pump; 400 h.p. B. and W. boilers, hand fired.

Yak Tunnel: Silver Cord property; two-drum electric hoist; motor driven compressors; compressed air and electric driven pumps; continuous current haulage.

Geology.

The Paleozoic series and fault systems are studied underground and the sharply defined moraines and other glacial phenomena, on the surface.

SHOSHONE.

Engineering.

Central Colorado Power Company's hydro-electric plant. Water from the Grand river is conducted through a tunnel cut inside of the mountain for approximately two and one quarter miles, delivered through penstocks to central discharge turbines under a head of 165 feet; ultimate capacity of plant approximately 25,000 h.p.; ultimate transmission voltage 100,000.

SHOSHONE AND GLENWOOD.

Geology.

Archaean gneiss and schist; unconformable above these are the Paleozoic rocks exposed in the canyon of the Grand river; typical canon erosion and travertine deposits. At Glenwood the Mesozoic rocks.

UTAH.

BINGHAM.

Mining.

This district permits the study of three distinct systems of mining, namely, the overhead stoping, the caving, and the open pit. The extensive properties of the Utah Consolidated Mining Company and the Utah Copper Mining Company are open to the unrestricted inspection of the class. Further interest in this district comes from the

opportunity to study aerial tram systems, difficult railroad engineering, and the operations of single companies under different systems.

Geology.

The Carboniferous quartzite and limestone, with intruded igneous masses that have marmorized the limestone at contact; the relationship of the ore bodies to these contact phenomena.

Engineering.

Utah Copper Company: steam power plant; capacity 10,000 boiler h.p.; 500 h.p. Heine boilers equipped with underfeed stokers; forced draft; concrete stacks; large cross compound Allis and Nordberg engines direct connected to a.c. generators; Wheeler surface condensers with independently driven Edwards air pumps.

American Smelting and Refining Company; steam power plant; large horizontal blowing engines; single stage air compressors driven by cross compound Corliss engines; Worthington surface condensers with Blake air and circulating pump; 500 h.p. Stirling boilers equipped with plain grates.

Salt Lake City.

Metallurgy.

Near Salt Lake City are located four large smelting plants. The American Smelting and Refining Company operates a lead smeltery at Murray and a copper smeltery at Garfield; the United States Smelting, Refining, and Mining Company, a lead smeltery at Midvale; and the International Smelting Company, a copper and lead smeltery at Tooele. At Garfield also are located the mammoth concentrating mills of the Utah Copper Company. At Salt Lake City the General Engineering Company has a plant for testing ores by various concentration and extraction processes.

Geology.

Excursion into the Wasatch range, to see the great synclinal fold and the Wasatch fault; very recent faults and glacial features; Lake Bonneville terrace formations.

PARK CITY.

Mining.

There are several large mining companies operating in this district. The most extensive of these is the Silver Coalition Mines Co. A great deal of money has been taken from the mine which yields rich silver lead ore. This mine has a very excellent underground hoisting station. The Silver King Consolidated, and the Daly-Judge are other important mines in this district.

Metallurgy.

The Silver King Coalition had quite a large mill equipped with flotation, which burned down about a year ago and is now in the process of rebuilding. The Daly-Judge Co., which mines a zinc ore, has an electrolytic plant for the production of metallic zinc.

Geology.

The country rock consists of folded and faulted Carboniferous and younger sediments, overlain by andesite and intruded by dikes, sills, stocks, and laccoliths of quartz diorite and quartz diorite porphyry. The ore deposits are of replacement origin and are developed both along fissures and bedding planes. The important ore minerals are galena, pyrite, chalcopyrite, sphalerite, tetrahedrite, and the products of oxidation.

MONTANA.

BUTTE.

Metallurgy.

The Precipitation plants: recovery of dissolved copper from mine waters; leaching and recovery of soluble values from dumps.

The Butte and Superior Mill; Timber Butte Mill.

Mining.

The mines of this district exhibit modern practices of lode mining in high grade copper ore. Among the noteworthy mining features studied are: deep mining with the involved difficulties of drainage, ventilation, and timbering; steel sur-

face structures; automatic loading and dumping of ore; rapid hoisting; mechanical framing of timbers; handling of large volumes of acid water; square set stoping; the driving of working levels in country rock; the naturally high temperatures of the working places; and the systematic recording of every operation. Mine and geological underground surveying are exemplified in the practices of the Amalgamated Copper Company.

Geology.

Secondary enrichment of original sulphide ores; the relationship of these ore bodies to the remarkable fault systems of Butte; the study of granite, aplite, porphyry, and rhyolite rocks.

Engineering.

Anaconda Copper Company: mine plant at the New Leonard, 3,500 h.p. Nordberg hoist; 150 foot steel head frame; two stage Nordberg air compressors rope driven by induction motors; locomotive type of boilers.

Anaconda Copper Company: mine plants at the Diamond and Bell mines; very large air compressing plant; two stage compressors equipped for either steam or motor drive; 3,000 h.p. Allis hoisting engine; marine type of boilers; high steel head frame with automatic dumping attachments.

Missouri River Power Company: steam power plant; Westinghouse - Parsons turbines, connected to a.c. generators; surface condensers with independently driven air and circulating pumps; B. and W. boilers equipped with Roney stokers; high tension current station used as relay for the company's hydro-electric plants and operated in parallel with them.

ANACONDA.

Metallurgy.

New Reduction Works of the Anaconda Copper Mining Company: track system for the delivery of ores and shipment of products; compressed air traction for yard haulage; concentrating mill of eight one thousand ton units; bin systems;

briquetting plant; largest furnaces in the world; reverberatory furnaces; converter plant; refining furnaces and casting department; arsenic plant, and flue systems. So much is to be seen here that considerably more time is spent in this plant than at any other point, and, owing to the courtesy of the management, much valuable instruction is possible.

The Anaconda Copper Mining Company: brick department; the manufacture of clay and silica brick of the highest degree of refractoriness and of all shapes.

Engineering.

New Reduction Works: general power plants; large triple expansion condensing Corliss engines belted to line shaft; two and four stage air compressors driven by cross compound Corliss engines; rotary blowers of the Connersville and Root types, direct connected to Corliss engines; rotary blowers, rope driven from induction motors; Stirling boilers equipped with plain grates; rotary converters and transformers for the high tension current brought in from the hydro-electric plants.

ELECTRICAL AND MECHANICAL POWER PLANT TRIPS The State of Colorado affords excellent opportunity for the study of the practical application of electrical and mechanical power in the mining and milling industry, as well as for lighting and manufacturing purposes. The various plants in Denver, Colorado Springs, Pueblo, Canon City, Glenwood Springs, and various other points in the State are visited.

OIL REFINERY TRIP This trip is planned for students enrolled in Chemistry XIX, XX, XXI or XXII and is made in connection with a junior or senior metallurgical trip. A visit is made to the plant of the United Oil Company, in Florence, Colorado. Here the student not only has an opportunity to inspect the equipment and operation of a "straight-run" refinery, but also a Burton "cracking" plant, an absorption gasoline plant, and plants for the manufacture of lubricating oil and wax. A trip is also made to the oil field and refineries in Wyoming.

CHEMISTRY INSPECTION TRIPS Chemical inspection trips are planned for the students of the junior and senior classes to the works of The Western Chemical Manufacturing Company, The Denver Fire Clay Company, The Great Western Sugar Company, The Holly Sugar Company, The Oil Refinery at Florence, and one of the nearby Portland Cement Works, to enable the student to observe the manufacture of acids, fire brick, beet sugar, and cement, and the refining of petroleum. These trips are preceded by explanatory lectures, that the student may understand and intelligently observe the various operations inspected.

GEOLOGY TRIPS During the junior year the students specializing in mining geology study the geology and ore deposits of the Idaho Springs area. The Pre-Cambrian gneisses and schists and their Tertiary intrusions are observed on the surface; then several of the more important mines of the district are visited, and the character of the veins and their relation to the country rock noted. At the close of the junior year the class in field geology spends two weeks in southern Wyoming. Practical experience in the geological mapping of oil structures in the Laramie basin is given, after which the geology of the Medicine Bow mountains is studied. Among the features shown are a great variety of Pre-Cambrian metamorphic and igneous rocks illustrating many characteristic structures, several mineral prospects, an elevated Tertiary peneplain, and a large assortment of glacial phenomena centering about the Snowy range.

COURSE FOR PROSPECTORS AND PRACTICAL MINING MEN

February 6, 1922, to March 4, 1922.

GENERAL DESCRIPTION The course for Prospectors and Practical Mining Men, which was inaugurated by the Colorado School of Mines in January, 1915, proved so popular and profitable to those who attended, that the course has been repeated. As a result of the success which attended this innovation, it has become an established part of the work of the Colorado School of Mines, and will be offered annually as long as there is any apparent need or demand. The next course will be given at Golden during the four weeks beginning February 6th, and ending March 4, 1922. It is planned to condense the work so as to keep the members occupied throughout each day. This will be an advantage from the point of view of instruction, and will make the course less expensive to those who attend. All of the courses are of the most practical nature, and comprise instruction in common minerals, ores, and rocks; elementary chemistry; principles of ore dressing, assaying, and the more common metallurgical processes; methods of valuing, buying, and selling ore; lode mining, location of mining claims; and petroleum engineering. They are given entirely by regular members of the faculty and consist of lectures, supplemented by practical laboratory demonstrations. Those who expect to take advantage of this course are asked to notify the school authorities as soon as possible, in order that the preparation may be made for the work. Address all correspondence to The Registrar, Colorado School of Mines, Golden, Colorado.

EXPENSES A single fee of ten dollars is charged for the entire course of four weeks, and is payable on registration. Board and lodging can be secured in Golden. Upon request made sufficiently in advance, the school will be glad to aid anyone in obtaining suitable accommodations. There are no dormitories in connection with the school.

HOW TO REACH GOLDEN Through tickets, over the Colorado & Southern Railway, may be purchased at any railroad station in Colorado direct to Golden. There are also two electric lines from Denver on half hour schedules during the day. The cars on these lines leave the station on Arapahoe street, between Fourteenth and Fifteenth streets, on the hour and half hour. The fare from Denver to

Golden is the same on each line, viz: 8 cents to the city limits and 34 cents thence to Golden. On reaching Golden board and room should be secured first. Students should then go to Guggenheim Hall and get a registration card from T. C. Doolittle, Registrar and Business Manager. Without this card, no one will be admitted to any course.

OUTLINE OF COURSES

COMMON ROCKS AND MINERALS

Professor J. J. Lillie

Eight hours of lecture and practical laboratory work a week.

This course is devoted to the study of common minerals, ores, and rocks. The instruction includes blowpipe reactions, and simple tests for identifying minerals and rocks in the field. Special attention is given to the properties and occurrence of the metallic minerals of economic importance.

GENERAL GEOLOGY; GAS AND OIL

Profs. F. M. Van Tuyl and J. H. Johnson

Three hours lecture work a week.

This course is devoted to such geological features as throw light on the origin and manner of occurrence of ore deposits, and on the structural features frequently met in mining. These latter include faults and folds, strikes and dips, and mutual relationship of rock masses. Particular attention is given to the kinds of rocks and geological conditions, which appear to effect ore deposition. An important part of prospecting is to know what may be sought for in the different formations. Gas and oil geology is a feature of this course.

CHEMISTRY

Prof. W. V. Norris

Two hours lecture, and six hours practical laboratory work a week.

The object of the course is to make the prospector more familiar with the use of such apparatus and chemicals as may aid him in supplementing his field work, and to equip him with knowledge of the characteristic properties of the common metals. Some work on the commercially rare metals is also given.

PETROLEUM ENGINEERING

Prof. W. K. Kirby

Three hours lecture a week.

This course includes a discussion of the methods of measuring, gathering, and storing of crude petroleum, as well as a short description of gathering systems and tank farms. An outline is given on the standard and hydraulic rotary systems of drilling.

The transportation of oil in pipe lines is discussed, and the light oil and heavy oil systems of pumping are compared. A non-technical description is given on the operation of oil refinery. Blue prints, catalogues, and specifications are used in order to show the practical apparatus in current use.

GENERAL METALLURGY

Prof. I. A. Palmer

Two hours a week.

A non-technical discussion of the production, statistics, uses, relative importance, properties, and metallurgy of the more common metals. The course includes an explanation of the methods of sampling and the manner in which ores and metals are bought and sold.

ORE DRESSING

Profs. Pfoutz and Maxson

Two hours of lectures and six hours laboratory work a week.

The lectures include brief outlines of the principal methods used in the concentration of ores. The reason for the various processes,, and the economic phases of the subject are emphasized. In the laboratory work a study is made of the mechanical equipment used in ore dressing. The functions of the principal apparatus, and the modifications made necessary by changing conditions are explained and illustrated.

IRON AND STEEL

Prof. C. Y. Pfoutz

One hour a week.

A discussion of the importance of iron and steel in industry and commerce, production statistics, the location of the principal iron mines and steel plants of the world, and a brief outline of the metallurgical methods used.

HYDROMETALLURGY

Prof. W. L. Maxson

One hour a week.

In these lectures attention is called to the great and increasing importance of leaching and electrolytic methods in the extraction and refining of metals. Brief outlines are given of these processes as applied to the metallurgy of gold, silver, copper, lead, and zinc.

ASSAYING

Mr. C. A. Townsend

Two hours a week.

These lectures include an outline of the practical methods used in the fire assay of gold, silver, and lead. The lectures are supplemented by an examination and discussion of the furnaces and apparatus used in the assay laboratory.

MINING CLAIMS

Prof. James Underhill

Three hours a week.

This course includes instruction in the methods of acquiring title to mineral lands in the United States. Practical methods of locating and surveying mineral lands are described, and instruction is given in the preparation and filing documents used in acquiring title to lode and placer claims; mill and tunnel sites; timber, stone, and coal lands; water rights. These courses includes a discussion of surface prospecting, methods employed, and equipment required.

LODE MINING

Dean Lester S. Grant

Two hours a week.

This course includes a discussion of the opening and development of prospects to the best advantage; also proper methods of sampling in the mine and on the dump.

RESERVE OFFICERS' TRAINING CORPS

The Colorado School of Mines maintains an Engineer Unit of the Senior Division of the Reserve Officers' Training Corps.

OBJECT The primary object of the Reserve Officers' Training Corps is to provide systematic military training at civil educational institutions for the purpose of qualifying selected students at such institutions as reserve officers in the military forces of the United States. It is intended to attain this object during the time that students are pursuing their general or professional studies with the least practical interference with their civil careers, by employing methods designed to fit men physically, mentally, and morally for the pursuits of peace as well as the pursuits of war.

GENERAL POLICY It is the announced policy of the War Department to obtain as reserve officers men who have graduated from the units of the R. O. T. C., so that in time of national emergency there may be instantly available a sufficiently large number of educated men; physically efficient and trained in the fundamentals of military science and tactics and fitted to lead intelligently the units of the armies upon which the safety of the country will depend. It is believed that such military training will aid greatly in the development of better citizens.

EDUCATIONAL AIM The course of study is designed to give to the student a training which will be as valuable to him in his industrial or professional career as it would be should the nation call upon him to act as a leader in its defensive forces.

UNIFORM EQUIPMENT All members of the R. O. T. C. at the school are provided by the United States Government with complete military uniforms including coat, breeches, hat, leggins, flannel shirts, and belt. These articles are issued to students free of charge, and must be returned at the end of the school year, or whenever a student severs his connection with the military department.

COURSE The Military Department offers a progressive course of four years consisting of two years' basic course and two years' advanced course. The basic course is required

of all freshmen and sophomores who are citizens of the United States, and who conform to the physical requirements. The successful completion of the basic course is a prerequisite for graduation. An elective advanced course of two years, includin one summer camp, is offered to students who have successfully completed the basic course, and who have been recommended by the President and the Professor of Military Science and Tactics for further training. The government offers a very liberal allowance to students enrolled in the advanced course in the matter of commutation of subsistence. At present the monetary allowance amounts to $12.00 a month. Students receive this from the beginning of their junior year to the end of their senior year, except during camp, when they are given rations in kind. After graduation students are eligible for appointment as second lieutenants, Engineers Officers' Reserve Corps. Students who desire to take examinations for appointment in the Corps of Engineers, and who graduate from the R. O. T. C., are exempt from the technical examinations. Enrollment in the R. O. T. C. does not make any student liable to any service under the War Department.

SUMMER CAMPS Two summer camps are held in connection with the course in Military Science and Tactics; the attendance is voluntary at the first, and compulsory at the second. Students may attend the basic camp while they are taking the basic course of the freshman and sophomore years. The second camp is for those students who have agreed to complete the advanced course.

The camps are of six weeks duration, and open within a few days after Commencement. Students attending these camps have their entire expenses paid, including transportation, sleeping car accommodations, and allowance of approximately $3.00 a day for meals while en-route both ways; an additional complete uniform upon arrival at camp; $1.00 a day in cash to those students pursuing the advanced camp course of instruction; board, lodging, medical, and dental treatment while at camp; and abundance of healthy, recreational amusement, and diversion; excellent social attractions; and last, but not the least, a course in military instruction of the very highest type, given by especially selected officers who are experts in their particular subjects.

CREDITS Graduates of junior units of the R. O. T. C. either in an essentially military school or in a preparatory school other than an essentially military school, that have satisfactorily completed two or more years of the course, are

given partial credit for the subject matter covered upon their entrance to the R. O. T. C. unit at this institution. In order to obtain credit, students must submit a detailed certificate as to the subjects covered, signed by a school officer, and P. M. S. & T. Credit is extended throughout the course according to the student's standing in the junior unit and his demonstrated ability. In this way students remain active members of the military department, make the acquaintance of the other students in the organization, and keep abreast of them in the military work. Students who have been members of the R. O. T. C. at other colleges or universities are given credit for the subject matter covered, upon presentation of records covering their work at their institutions.

SUMMER SCHOOL

The Summer School is organized for the benefit of irregular matriculated students, and also for prospective students who desire to complete the requirements for entrance. The work given is adapted to the needs of the individual. Consequently, not an entire course, but only portions of it, may be given, according to circumstances. Prospective students should, before planning to take work in the summer school, ascertain that it meets their needs. Instruction is given by the regular members of the faculty. A laboratory deposit, to cover the cost of material used, is required in each laboratory course, any unused portion of which is returned. The numbered courses are described in the catalog. The schedule of hours will be arranged on the opening day. A lecture course may not be given for fewer than six students, consequently early notice of intention to enter is necessary. Instruction is given by regular members of the faculty. The school begins Monday, July 24, 1922, and closes Saturday, September 2, 1922.

The following courses are offered:

Requirements for entrance.

Review Algebra ....Fee	$ 5.00
Solid Geometry ....Fee	5.00
Chemistry ....Fee	10.00
Physics ....Fee	5.00

College Courses:

Mathematics.

Mathematics	I	Unified Mathematics
"	III	Analytic Geometry
"	IV	Elementary Calculus
"	V	Calculus
"	VI	Calculus

The fee for each of these courses is $5.00.

Chemistry:

Lecture Courses.

Chemistry	III	Qualitative Analysis
"	IV	Qualitative Analysis
"	VII	Quantitative Analysis
"	VIII	Quantitative Analysis

The fee for each of these courses is $5.00.

Laboratory Courses:

Chemistry	V	Qualitative Analysis
"	VI	Qualitative Analysis
"	IX	Quantitative Analysis
"	X	Quantitative Analysis

The fee for each of these courses is $10.00.

Mechanical Engineering:

Mech. Eng.	V	Machine Design, Lectures
" "	VII	Kinematics of Machinery, Lectures
Mech. Eng.	VI	Machine Design, Drawing
" "	VIII	Kinematics of Machinery, Drawing

Descriptive Geometry:

Des. Geom.	I	Lectures
" "	III	Lectures
" "	II	Drawing
" "	IV	Drawing
" "	V	Drawing

The fee for each of these courses is $5.00.

Metallurgy:

Lectures.

Metallurgy I Assaying ....Fee $5.00

Laboratory.

Metallurgy II Assaying ....Fee $20.00

For further particulars address The Registrar, Colorado School of Mines, Golden, Colorado.

SCHOLARSHIPS

RESOLUTION OF THE BOARD OF TRUSTEES
COLORADO SCHOOL OF MINES
June 6, 1921

RESOLVED, That in lieu of all previous action of the Board of Trustees, a scholarship is defined and shall be awarded only as follows:

A scholarship is defined as the remission of the required tuition and laboratory fees.

Scholarships may be awarded by the Board of Trustees upon recommendation of the President of the Faculty.

Scholarships are hereby authorized, and may be granted annually to:

1. One graduate of each Colorado accredited high school.
2. One to each state, the District of Columbia, Alaska, and the insular possessions of the United States, upon the request or nomination of the proper educational authority.
3. To foreign countries or governments, not to exceed twenty, upon the recommendation of the President of the Faculty.
4. Including the year beginning 1922, such army and navy scholarships as the President of the Faculty may recommend, and the Board of Trustees approve.

Scholarships are awarded to applicants for admission who show proficiency in their studies and are recommended by the proper school officials. A candidate must satisfy the requirements for entrance and file his application, with recommendations, on or before July 1 following his graduation. Students graduating from high school or academy during the year when application is made are the only ones eligible for scholarships other than the army and navy scholarships. A scholarship relieves the holder of all tuition and laboratory fees for a period of four years, but will be terminated if the holder does not maintain a satisfactory standing in his studies, or does not comply with the requirements of the faculty or the trustees.

UNITED STATES ARMY AND NAVY SCHOLARSHIPS These scholarships are available to officers and men who are honorably discharged from the Army or Navy or the Marine Corps of the United States, who were in service during the late war, and may be

awarded by the President of the school to candidates who are recommended by the proper Army or Naval official. They are intended to benefit men who gave up their college career to enter the service and who, after the war, wish to complete their college course. To non-residents of Colorado these scholarships have an annual value of approximately $250.00.

UNITED STATES SCHOLARSHIPS A scholarship is awarded each year to each State in the Union on the recommendation of the State Superintendent of Public Instruction. It has an annual value of approximately $250.00.

COLORADO SCHOLARSHIPS A scholarship is given each year to each of the accredited high schools of the State of Colorado. It is awarded on the recommendation of the principal, and has an annual value of approximately $50.00.

COLORADO LABOR EDUCATION ASSOCIATION SCHOLARSHIPS Five scholarships are awarded annually on the recommendation of the Colorado Labor Education Association. They have an annual value of approximately $50.00.

FOREIGN SCHOLARSHIPS Scholarships are awarded to each of the Latin-American countries, to each of the provinces of Canada, to Cuba, Porto Rico, China, and to the Philippine Islands. They have an annual value of approximately $250.00. These scholarships are awarded on the recommendation of the following officials:

CENTRAL AMERICA

Costa Rica, San José..............Minister of Public Instruction
Guatemala, Guatemala............Minister of Public Instruction
British Honduras, Belize...................Inspector of Schools
Honduras, Tagucigalpa............Minister of Public Instruction
Nicaragua, Managua..
.......Minister of Foreign Relations and Public Instruction
Salvador, San Salvador..........Secretary of Public Instruction
Panama, Panama...............Secretary of Public Instruction

WEST INDIES

Porto Rico.................Superintendent of Public Instruction
Cuba......................Superintendent of Public Instruction

SOUTH AMERICA

Argentina, Buenos Aires..........Minister of Public Instruction
Bolivia, Sucre........Minister of Justice and Public Instruction
Brazil, Rio de Janeiro......................................
.........Minister of Justice, Interior and Public Instruction

Chile, Santiago....................Minister of Public Instruction
Colombia, Bogota..................Minister of Public Instruction
Ecuador, Quito....................Minister of Public Instruction
Paraguay, Asuncion......................................
........Minister of Justice, Worship and Public Instruction
Peru, Lima...........Minister of Justice and Public Instruction
Uruguay, Montevideo.............Minister of Public Instruction
Venezuela, Caracas................Minister of Public Instruction

CANADA

Alberta, Edmonton...........Chief Superintendent of Education
British Columbia, Victoria...Chief Superintendent of Education
Manitoba, Winnipeg......................Minister of Education
New Brunswick, Frederickton.............................
........................Chief Superintendent of Education
Nova Scotia, Halifax.........Chief Superintendent of Education
Ontario, Toronto.........................Minister of Education
Prince Edward Island, Charlottetown......................
............Chief Superintendent of Education and Council
Quebec, Quebec...................Council of Public Instruction
Saskatchewan, Regina....................Minister of Education
Yukon Territory, Dawson...Superintendent of Public Instruction

CHINA

Washington, D. C. ....Director of Chinese Students

Philippine Islands, Manila..Superintendent of Public Instruction
Mexico, D. F..............Director General of Public Education

STUDENT ORGANIZATIONS

STUDENT COUNCIL

Affairs of the students as a body, and matters pertaining to college life generally, are under control of the Student Council, which is composed of representatives of the various school organizations. The president of the council is chosen by vote of the entire student body; the other members are selected by the organizations which they represent.

The following are the officers and members for the year 1921-1922:

T. G. Foulkes, '22,	President and Stray Greek representative
L. S. Woeber, '22,	Secretary and M. E. T. representative
A. B. Martin, '23,	Barb representative
H. A. Harris, '23,	Barb representative
T. H. Huang, '22,	Chinese Club
Salvador Ortiz, '23,	Latin-American Club
R. M. Edwards, '23,	Kappa Sigma Fraternity representative
N. W. Hyland, '22,	S. A. E. Fraternity representative
John Robertson, '23,	Sigma Nu Fraternity representative
R. K. DeFord, '20	Barb representative
A. E. Jenni, '21	Barb representative

BAND

The school is justly proud of a band of 35 pieces, which plays at all football games, athletic events, and gives monthly concerts throughout the school year. It is under the direction of Professor A. E. Bellis.

THE OREDIGGER

This is a weekly newspaper, owned, edited, and managed by the students. It is devoted to news of the school, and serves as an open forum for discussion of all matters on which the students wish to be heard.

STAFF

E. R. Aaron, '22 .... Editor
W. M. McGill, '22 .... Assoc. Editor
J R. Dorrance, '22 .... Asst. Editor
L. J. Parkinson, '23 .... Business Manager

J. A. Peck, '23 .... Asst. Bus. Manager
B. H. Parker, '24 .... Asst. Bus. Manager

C. W. Guth, '22	M. R. Budd, '24
E. F. Bruhn, '23	K. P. Hurley, '22
R. C. Maxwell, '23	J. H. Denny, '23
V. L. Denunzio, '23	F. W. Dakin, '23
E C. Gregg, '22	

OTHER ORGANIZATIONS AND CLUBS

RADIO SOCIETY—R. B. Downing, '24, President
GLEE CLUB—Mrs. F. M. Van Tuyl, Directress
"M" CLUB—N. W. Hyland, '22, President
TROWEL CLUB—A club for Master Masons
LATIN-AMERICAN CLUB—Salvador Ortiz, '23, President
CHINESE CLUB—T. H. Huang, '23, President
TEXAS CLUB—F. E. Bruhn, '22, President
STRAY GREEKS—T. G. Foulkes, '22, President
FRATERNITIES—Sigma Nu, Sigma Alpha Epsilon, Kappa Sigma, Beta Theta Pi, Mu Epsilon Tau (local).
HONORARY FRATERNITIES—Tau Beta Pi, Theta Tau
THE 1923 PROSPECTOR (The College Annual)—A. B. Martin, '23, Editor in Chief; V. L. Denunzio, '23, Business Manager.
MINEN CLUB—John P. Evans, '22, President
OHIO CLUB—Thomas G. Foulkes, '22, President
TRIANGLE CLUB—J. R. Dorrance, '22, President

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

JUNIOR AFFILIATED SOCIETY

This society has been in existence in the school for many years as the "Scientific Society of the Colorado School of Mines", but lately has been merged with the American Institute of Mining and Metallurgical Engineers, as a Junior Affiliated Society. It now numbers more than two hundred students, and is the largest Junior Affiliated Society of the Institute. The discussions and deliberations of the society are open to all students, whether members or not. The members automatically become a part of the Colorado Section.

The officers for the year 1921-1922 are:

President—Theodore Marvin, '22
Vice-President—A. C. P. Wong, '23
Secretary—H. Ray Lee, '23

The society is divided into four sections, each with its chairman:

Mining section	F. L. Serviss, Chairman
Metallurgical section	T. G. Foulkes, Chairman
Geological section	D. S. Harroun, '22, Chairman
Oil section	G. W. Machamer, Chairman

Monthly meetings are held. At each alternate meeting the society as a whole transacts its business, after which the various sections adjourn to different rooms, where papers of interest to each group are read and discussed. At other general meetings, lectures are delivered by leading engineers and scientific men. Members are designated by (*) in the enrolment of students.

The faculty members of the A. I. M. & M. E. are as follows:

President Victor C. Alderson
Dean Lester S. Grant
Professor I. A. Palmer
Professor F. M. Van Tuyl
Professor J. Harlan Johnson
Professor Will V. Norris
Professor W. L. Maxson
Professor C. Y. Pfoutz
Professor J. J. Lillie
Professor James Underhill
Professor J. H. Johnson
Frank D. Aller
C. A. Townsend
John C. Williams
James C. Roberts

The Trustee members are:

William D. Waltman
Lewis B. Skinner

THE RADIO STATION

Within the past two years, mining corporations have seriously considered radio communication in preference to line telephones for isolated camps. In accordance with this advancement, the Colorado School of mines opened and installed a complete radio telegraph station January 1, 1921. Radio Station 9XAI was licensed by the United States Government February 1, with C. E. Heffelman, '23, as operator in charge. Radio communication was first carried on with the South Dakota School of Mines, a distance of four hundred fifty miles. Interest was immediately aroused among the student body, and resulted

in the organization of the Radio Society. The receiving equipment includes a "Grebe Special" Receiver, type RC, with two steps of audion amplification. A regenerative connection is now used. The sending equipment comprises a one kilowatt closed core transformer, rotary quenched spark gap, oil-immersed condenser, and oscillation transformer, with protective devices of the most modern design. A one hundred watt radio telephone set is to be installed in the near future. The present range of the receiving equipment is two thousand miles. Signals have been distinctly heard from Havana, Cuba, and from Honolulu, Hawaiian Island. The transmitting range is one thousand miles.

R. B. Downing, '23, was elected president of the Radio Society for the fall term of 1921. A month later, classes in radio installation were organized under the instruction of C. E. Heffelman, '23. There is at present an enrolment of twenty-two students. It is the intention of the Radio Society to conduct a number of experiments in radio communication between Golden and several prominent Colorado mining camps.

GRADUATE FELLOWSHIPS

The Colorado School of Mines offers fellowships in Mining, Metallurgical, Geological, and Chemical Research. These fellowships are open to graduates of universities and technical schools who are qualified to undertake research. The value of each fellowship is $900.00, payable in twelve monthly installments of $75.00 each. Fellowship holders must be graduates of colleges, universities, or technical schools of good standing. During the college year they will be required to devote fifteen hours a week to the school as laboratory assistants. The remainder of the time they may pursue advanced studies and become candidates for higher degrees as indicated under the subject of degrees or may engage in research work. The purpose of these fellowships is to undertake the solution of problems in mining, metallurgy, and metallurgical chemistry which are of special importance to the State of Colorado. Subjects for research may be selected from the following general fields:

1. Pyrometallurgy, electrometallurgy, and other methods of metal extraction.
2. Metallography and the heat treatment of metals.
3. Ore dressing, including concentration by wet and dry methods, flotation, electromagnetic and electrostatic separation.
4. Utilization of the rare metal resources of Colorado.
5. Problems involved in the development of the Oil Shale industry.
6. Radioactivity, radioactive transformations, and the study of radioactive minerals.

Facilities of the Metallurgical Research Laboratory and of the various chemical, metallurgical, and mechanical laboratories of the Colorado School of Mines will be available for the use of holders of the graduate research fellowships.

Applicants should send a copy of their collegiate records from the Registrar's office of the college where they have been, or will be, graduated. They should also state their professional experience and give the names and addresses of at least three persons who are familiar with their character, training, and ability. Applications should be addressed to the President of the Colorado School of Mines, Golden, Colorado.

GENERAL INFORMATION

TUITION

The Statutes of Colorado provide as follows:

> "The said School of Mines shall be open and free for the instruction to all bona fide residents of this State, without regard to sex or color, and, with the consent of the Board, students from other states and territories may receive education thereat upon such terms and at such rates of tuition as the Board may prescribe."

The tuition for non-residents is one hundred fifty dollars a year, payable in two installments, seventy-five dollars at the beginning of each semester.

DEPOSITS Deposits are required to cover the cost of supplies consumed. Any unused balance is returned. Drawing and locker deposits are returned when a student leaves school.

For courses in Chemistry	$10.00
For Metallurgy II	50.00
For drawing, small board (paid only once)	2.50
For drawing, large board (paid only once)	7.50
For locker (paid only once)	1.00

GENERAL FEES Fees are charged to cover not only the cost of materials and supplies furnished, but also the wear on apparatus. No part of a fee is returnable. The athletic fee, although collected by the school, is turned over to the Treasurer of the Athletic Association, and is expended only for athletic purposes.

Matriculation fee	$ 5.00
Athletic fee (paid each semester)	8.00
Band Fee (paid each semester)	1.00
Graduation fee	5.00
Thesis fee	5.00
For registration later than the dates assigned for registration	1.00

LABORATORY FEES Chemistry V, VI, IX, X, XII, XIV, XVI, XVIII, XXII, XXIII, XXIV, XXV, XXVI, XXX, XXXI, XXXII, XXXVII, XXXVIII, XL, XLI, XLII (each) $10.00

Civil Engineering II	10.00

Civil Engineering IX and XI (each)	$ 5.00
Electrical Engineering II, IV and VI (each)	5.00
Geology III, IV, and XIII (each)	10.00
Geology VII, IX, XIV, XVI, and XIX (each)	5.00
Geology VIII	15.00
Mechanical Engineering XVIII	5.00
Metallurgy II	20.00
Metallurgy VIII, IX, XVI, and XIX (each)	5.00
Metallurgy XIII, XV, and XXI (each)	10.00
Metal Mining III, and IV (each)	10.00
Physics II, IV, VII, VIII, and IX (each)	5.00

BOARD AND LODGING The school has no dormitory. Board can be obtained in private families for thirty to thirty-five dollars a month. Students' clubs furnish board for about thirty to thirty-five dollars a month. Rooms can be obtained for eight dollars to fifteen dollars a month.

OTHER EXPENSES There are other expenses incidental to the mining, metallurgical, engineering, chemical, and geological trips, which vary so widely that they cannot be estimated. Students leaving in mid-term, except on account of severe or protracted sickness, are not entitled to the return of fees or tuition. **All charges of the school are payable strictly in advance at the beginning of each semester.** No student is allowed to be graduated while indebted to the school. The Trustees reserve the right to make incidental changes in fees and deposits without printed notice, as new and unforeseen emergencies may arise. Students who desire to earn money to defray their school expenses are advised to limit their work to the summer vacation. The course of study is too exacting to allow much time during the college year for outside work.

THE QUARTERLY Four times a year, in January, April, July, and October, the school issues the Quarterly. The various numbers include the Catalog, the Book of Views, Commencement addresses, and articles of a mining or of a metallurgical nature.

METHOD OF GRADING The following system of grading is used:

A—Excellent
B—Good
C—Fair
D—Conditioned
E—Failed or Subject Dropped

A, B, and C are passing grades.

D (Conditioned) means that the student is not passed. The deficiency may be removed by passing a re-examination or by otherwise completing the work. Unless a condition is removed before the beginning of the next school year the D becomes an E.

E (Failed or Subject Dropped) means that the subject must be taken again, and that no subject depending upon this one may be taken until the E is removed. In removing an E the student must take the subject again either at a regular period or under conditions approved by the head of the department.

Three hours of laboratory or of drawing are regarded as the equivalent of one lecture or recitation hour.

In case a student fails to complete his work in any subject the instructor may, at his discretion, report to the office not a D but an "Incomplete", which shall be designated by the letters "Inc." This is not regarded as a condition, but it becomes an E at the beginning of the next school year unless previously removed.

In case a student leaves school with one or more conditions and returns after an absence of a year or more, the term "next school year" will be interpreted to mean the next school year of his attendance; but in case he leaves at the close of the first semester he may return at a similar period a year or more later, subject to the conditions under which he left, as though there had been no break in his attendance, except in case of a changed curriculum.

THE INTEGRAL CLUB The Club Room is in the Gymnasium building, and is furnished in the ordinary style of a gentleman's club. The purpose of the Club is to foster good comradeship among the students.

ATHLETICS AND PHYSICAL TRAINING By virtue of the athletic fee required, all students entering the School of Mines become members of the Athletic Association. The Association is supported by the student fees, gate receipts, and by contributions from the alumni and other friends of the school. The affairs of the Association are managed by an Athletic Council, which consists of two members of the Faculty of professorial grade, two members of the senior class, all four elected by the student body, and an Athletic Director, appointed by the Board of Trustees, who is a regular member of the Faculty. The Athletic Association maintains an office in the gymnasium building, under the supervision of the athletic director. Physical training is required in regular gymnasium classes during the freshman and sophomore years. This work, however, is

replaced by those who engage in the major sports: i. e. football, basketball, baseball, and track work. The members of the Athletic Council are F. D. Aller, President; Dean Lester S. Grant, Prof. A. E. Bellis, Hale Strock, '22, L. C. Squire, '22.

ALUMNI ASSOCIATION The aim of the Alumni Association is to promote acquaintance and friendship among the graduates, to encourage them to aid each other, and to make an organized effort to elevate and uphold the reputation and standard of their Alma Mater. To carry out these ideas, the Association, under the management of an Assistant Secretary and Treasurer, publishes monthly the Alumni Magazine, and conducts an employment bureau, or Capability Exchange, for the benefit of the members. All graduates are earnestly requested to join the Association, and to keep the assistant secretary and treasurer advised of their addresses and occupations.

The Officers of the Association are:

Thos. S. Harrison, '08 .... President
Eugene Snedaker, '14 .... Vice-President
Frank Reinhard, '04 .... Secretary
Chas. Rath, '05 .... Treasurer

E. R. Ramsey, '12
H. C. Watson, '01 } Executive Committee
Fred Jones, '00

K. G. Link, '08 .... Editor and Asst. Secretary

THE LIBRARY The school library occupies one-half of the second floor of Guggeheim Hall. The room is well lighted and ventilated, and has a seating capacity for one hundred twenty readers. The library contains sixteen thousand one hundred fifty bound volumes, and sixteen hundred unbound pamphlets and bulletins, principally of a technical nature, and is being increased in subjects corresponding to instruction given in the school. Of these accessions about one half comes from binding periodicals and serials, one hundred fifty of which are received by subscription, and many by gifts and exchange. Direct access to the shelves is permitted to all students in order that they may obtain the benefit of examining the books themselves, and no restrictions are placed upon the use of the books, except such as are necessary to give all readers an equal opportunity and to provide for a reasonable and proper care of the books. Books which are not needed for special reference work are loaned for home use for a period of two weeks. The card catalogue includes entries under author, title, and sub-

ject, arranged on the dictionary plan. The classification is an adaptation of the Dewey decimal system to the needs of a technical library.

The library subscribes to the publications of the leading scientific societies of the world and to the chief literary and scientific periodicals. It is especially rich in files of engineering journals, the material in which is available for ready reference through excellent periodical indexes. The library is a depository for the documents of the United States Geological Survey and United States Bureau of Mines, and has an unusually complete collection of the publications issued by state geological surveys and mining bureaus both in this country and abroad. Moody's Investor's Service, Babson's reports, and the weekly bulletins from various leading financial companies are received and kept on one of the reading tables for handy reference.

During the academic year the library is open from 8 a. m. to 12:30 p. m.; from 1:30 p. m. to 5 p. m., and from 7 p. m. to 10:00 p. m., except on Saturdays and holidays. The library is closed Saturday afternoons and Sundays.

PRIZES.

Each year, at Commencement, prizes are awarded by the Trustees on the recommendation of the Faculty to members of the graduating class who have maintained an excellent scholastic record, or have distinguished themselves for all around prominence in athletics, scholastic attainments, and prominence in school activities, or who have done exceptional work in some particular subject.

At the Commencement exercises, June 10, 1921, the Wolf medal, presented by Harry J. Wolf, of the class of 1903, was awarded to George Dewey Thomas for high scholastic attainments.

At the Commencement exercises, June 10, 1920, the Brunton transit—given annually by the Jefferson County Power and Light Company—was awarded to George V. Dunn for preeminence in athletics, leadership in student activities, and proficiency in scholarship.

Professor Arlington P. Little offers annually a gold medal for meritorious work in electricity as applied to mining and metallurgy.

The Denver Fire Clay Company offers an annual prize for proficiency in chemistry.

Thomas S. Harrison, '08, President of the Alumni Association, offers a prize of $25.00 for meritorious work in Petroleum Engineering.

The Denver Rock Drill Manufacturing Company offers an annual prize for meritorious work in Mechanical Engineering.

A. E. Wilson of Wilson, Cranmer & Co., Denver, offers annually a cash prize of $50.00 for meritorious work in pure and applied Mathematics.

W. A. J. Bell, of Denver, offers a prize of $25.00 for meritorious work on radium.

D. W. Brunton, Denver, offers a Brunton transit for meritorious work in surveying.

LOAN FUNDS The following loan funds have been established to assist worthy and deserving students through school.

The Natalie H. Hammond Loan Fund of $1,000.00 was donated to the school in July, 1909, by Mr. John Hays Hammond.

The Vinson Walsh Loan Fund of $1,000.00 was donated to the school in May, 1908, by Mr. Thomas F. Walsh, in memory of his son Vinson Walsh.

The Walter Lowrie Hoyt Loan Fund of $2,000.00 was donated to the school in May, 1912, by Mrs. Mattie B. Hoyt, in memory of her husband, Walter L. Hoyt.

Forty-four students have received financial assistance from these funds.

ENROLMENT OF STUDENTS

Students designated by (*) are Junior Associate members of the American Institute of Mining and Metallurgical Engineers.

POST GRADUATES

Belleau, Floyd M. .... Golden, Colo.
B. S. Oklahoma A. and M. College

Brown, Prentiss F. .... Denver, Colo.
E. M. Colorado School of Mines

Butcher, Cary P. .... Denver, Colo.
B. S. University of Kansas

Capshaw, Elmer .... Golden, Colo.
A. B. University of Oklahoma

*Davis, Arthur D. .... Appleton, Wis.
A. B. Lawrence College

*De Ford, Ronald K. .... Golden, Colo.
E. M. Colorado School of Mines

*Fenton, Clyde H. .... Neenah, Wis.
A. B. Lawrence College

*Flint, Howard T. .... Denver, Colo.
E. M. Colorado School of Mines

Fopeano, Helena .... Abingdon, Va.
B. S. Columbia University

*Foulkes, Thomas G. .... Columbus Grove, Ohio
B. S. Miami University

Jones, Fitzhugh B. .... Gloucester, Va.
B. S. Virginia Military Institute

*Krieger, Franklin O. .... Wichita, Kan.
A. B. Fairmount College

Lansing, Arthur C. .... Cambridge, N. Y.
A. B. Cornell University

*Machamer, George W. .... Baltimore, Md
E. M. Colorado School of Mines

Mull, Jay B. .... Homer, Ind
B. S. Purdue University

Packard, Sidney A. .... Oklahoma City, Okla
A. B. Cornell University

Ryan, Christopher W. .... Lynchburg, Va
A. B. University of Virginia

*Serviss, Frederick L. F. .... Golden, Colo
E. M. Colorado School of Mines

Shen, Mung Chin .... Kiu Kiang, China
A. B. University of Colorado
M. A. University of Colorado

Wood, Charlton T. .... Salem, Va.
A. B. Roanoke College

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Vice-President .... Robert W. Litheredge
Secretary .... Yen C. Sun
Treasurer .... Harold H. Christy

Aaron, Eugene R. .... Denver, Colo.
*Allan, Rex J. .... Grand Island, Nebr.
*Bacca, Joseph P. .... Trinidad, Colo.
*Baekeland, George W. .... Golden, Colo.
Cornell University
*Bilheimer, Earl L. .... Denver, Colo.
*Boatright, Byron B. .... Golden, Colo.
*Bond, Fred C. .... Wheatridge, Colo.
University of Denver
*Brown, George R. .... Denver, Colo.
Rice Institute
University of Texas
*Bruhn, E. Erich .... San Antonio, Tex.
*Bunte, Arthur H. .... Denver, Colo.
Christy, Harold H. .... Fort Townsend, Wash.
Missouri School of Mines
Clough, Richard H. .... Colorado Springs, Colo.
*Collier, Malcolm E. .... Denver, Colo.
Colorado Agricultural College
*Connors, Hugh M. .... Denver, Colo.
*Crawford, Paul W. .... Cooperstown, N. Dak.
Jamestown College
Crawford, William P. .... Charleston, W. Va.
Cunningham, Joseph M. .... Golden, Colo.
*Dorrance, James R. .... Bishop, Calif.
Drake, Cecil .... Lyons, Kansas
*Evans, John R. .... Chillicothe, Mo.
Missouri School of Mines
University of Missouri
*Farlow, Clarence A. .... Pueblo, Colo.
University of Missouri
Ferguson, Robert D. .... Pueblo, Colo.
Fong, Kin Lan .... Washington, D. C.
Government University, Peking, China

*Foo, Keat Kheng .... Penang, Straits Settlements
University of Hong Kong, China
University of Cambridge, England
Gibbons, Edward T................................Denver, Colo.
*Goodier, Benjamin D..............................Denver, Colo.
*Gregg, Donald C. .... Denver, Colo.
Guth, Clarence W................................Golden, Colo.
*Harroun, Daniel S.............................Malaga, N. Mex.
University of California
Haskin, Joseph A..........................Chattanooga, Okla.
St. Mary's College
*Henderson, James S. .... Montrose, Colo.
University of Colorado
*Herbert, George T......................New York City, N. Y.
Brooklyn Polytechnic Institute
*Hicks, Eugene H. .... St. Paul, Minn.
MacAlester College
*Houssels, John K. .... Long Beach, Calif.
*Huang, Kuo-Yin .... Changsha, Hunan, China
Government University, Peking, China
*Hurley, Keith P. .... Denver, Colo.
*Hyde, Pitt W. .... Hydeville, Vt.
Hyland, Norbert W..............................Denver, Colo.
*Jenni, Alfred E.................................Pueblo, Colo.
Johanson, Neil E.............................Seattle, Wash.
*Johnson, Frank ....Denver, Colo.
*Johnson, Ward K. .... Dickinson, N. Dak.
University of North Dakota
Jones, David L. .... Denver, Colo.
University of Colorado
*Kirby, Frederick W. .... Staunton, Va.
Virginia Polytechnic Institute
*La Follette, Bruce B. .... Greeley, Colo.
*Laskowitz, Samuel G. .... Denver, Colo.
*Leach, Paul R. .... Indianapolis, Ind.
Purdue University
Litheredge, Robert W. .... Casper, Wyo.
*Litheredge, Roland T. .... Casper, Wyo.
*Lowe, Rupert B.............................Weatherford, Texas
Baylor University
U. S. Naval Academy
Lu, Robert P. .... Chu-tan, Kiangsu, China
Government University, Peking, China
*Marvin, Theodore .... Golden, Colo.
Mayer, Walter...................................Chicago, Ill.
Lane Junior College

*McGill, William M. .... Petersburg, Va.
Virginia Military Institute
*McMenemy, James P. .... Denver, Colo.
*Millar, Wilton T. .... Front Royal, Va.
Virginia Military Institute
*Moreno, Domingo .... Santiago de Chile, S. A.
*Mossman, Howard W. .... Newark, Ohio
Carnegie Institute of Technology
Denison University
*Mueller, Nathan .... Boehringen, Germany
University of Washington
McMinnville College
*Nachtman, Jack S. .... Golden, Colo.
Michigan College of Mines
College of the City of New York
*Peet, Vincent C. .... Denver, Colo.
Los Angeles Junior College
*Pierce, Albert L. .... Boulder, Colo.
*Pratley, Henry H. .... Beaver Dams, N. Y.
*Reed, Ethbert F. .... Golden, Colo.
*Rhodes, Louis C. .... Havana, Cuba
*Riley, John A. .... Bridgeport, Conn.
Lehigh University
*Robertson, John, Jr. .... Pueblo, Colo.
University of Colorado
*Savage, Eros M. .... San Diego, Calif.
*Schoder, William P. .... Denver, Colo.
*Seemann, Arthur K. .... Brooklyn, N. Y.
*Simons, Paul C. .... Belen, N. Mex.
University of New Mexico
Colorado College
*Squire, Latham C. .... New York City, N. Y.
University of Virginia
Stovall, Preston W. .... Denver, Colo.
*Strock, Hale M. .... Denver, Colo.
Sun, Yen C. .... Peking, China
Tsing Hua College
*Valdez, Don C. .... Salida, Colo.
*Van Gilder, Charles P. .... Morristown, N. J.
*Woeber, Lorenz S. .... Denver, Colo.
Yu, Wu Heng .... SingChankaien, Chekiang, China
Government University of Peking

JUNIORS

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Vice-President .... George W. Clarke

Secretary .... E. Milburn J. Alenius
Treasurer .... Eugene J. Harvey

*Adams, James V. .... Taylor, Tex.
A. & M. College of Texas
Virginia Military Institute
*Alenius, E. Milburn J. .... Denver, Colo.
*Arms, Frank C. .... Walsenburg, Colo.
University of Missouri
Barlow, Cecil .... Eau Claire, Mich.
*Baroch, Charles T. .... Golden, Colo.
Beck, Adolph W. Jr........................Birmingham, Ala.
University of Alabama
Benjamin, Milton J............................Denver, Colo.
*Berner, Vernon T.......................Jamestown, N. Dak.
University of North Dakota
Binyon, Eugene O. .... Houston, Tex.
Notre Dame University
*Blamey, Sanford E...........................Montrose, Colo.
*Bowen, Max W.................................Upland, Ind.
Taylor University
*Brook, Charles C...........................Miles City, Mont.
*Brook, Edward J...........................Miles City, Mont.
*Brown, Firman H. .... Brookville, Penn.
Cairns, James H..............................Colfax, Wash.
State College of Washington
*Carpenter, Horace F. .... Denver, Colo.
University of California
Chang, Marshall H. .... Peking, China
Tsing Hua College
Chock, Goon F.............................Honolulu, Hawaii
Clarke, George W.....................Oklahoma City, Okla.
Clopton, John H. .... San Antonio, Tex.
Crawford, George W.........................Hoquiam, Wash.
*Crawford, Ronald F. .... Hoquiam, Wash.
Leland Stanford Jr. University
*Dakin, Francis W.............................Evanston, Ill.
*Dannettelle, Merle Q. .... Seymour, Ind.
Purdue University
*Denny, John H. .... Washington, D. C.
*Denunzio, Vincent L.........................Louisville, Ky.
Dinwiddie, Hardaway H...................San Antonio, Texas
Rice Institute
Edwards, Robert M. .... Golden, Colo.
Eslick, Louis H. .... Rockwell City, Ia.
University of Iowa

Ettington, Martin .... Golden, Colo.
Crane Junior College
Armour Institute of Technology
*Fairbairn, Frank M. .... Berthoud, Colo.
*Farmer, Ray J. .... Golden, Colo.
Cornell College
Fidel, Henry P. .... Grand Junction, Colo.
Fishwild, Allison A. .... Wyoming, Ia.
Coe College
*Fosdick, Arthur R. .... Denver, Colo.
*Freeman, William A. .... Denver, Colo.
*Gebo, William M. .... New York City, N. Y.
Superior State Normal School
*Gilkinson, Warren .... Denver, Colo.
Grant, Paul A. .... Columbus, Mont.
*Gray, William P. .... Tulsa, Okla.
Griggs, Truman A. .... Pasadena, Calif.
Throop College of Technology
Hackett, Cortez P. .... Golden, Colo.
*Hambly, Allen E. .... West Bridgewater, Mass.
Hamilton, Perry L. .... Craig, Colo.
Hardy, James W. .... Columbia, Mo.
University of Missouri
Harris, Harold A. .... Golden, Colo.
Drake University
*Harvey, Eugene J. .... Chicago, Ill.
University of Wisconsin
*Herron, John C. .... Telluride, Colo.
Massachusetts Institute of Technology
Hill, Myron G. .... Cleveland, Ohio
University of Michigan
Hoxsie, Reginald H. .... Winslow, Ariz.
Huang, Tzu Hsiang .... Peking, China
Tsing Hua College
Jones, Neil M. .... White Pine, Colo.
Jordan, Charles F. .... Denver, Colo.
Baker University
*Keightley, Walter A. .... Pleasant Hill, Ill.
*Knill, Raymond R. .... Lafayette, Colo.
*Krantz, Percy R. .... Dunton, Colo.
*Larson, Carol B. .... Boise, Idaho
*Larson, Edward S. .... Chicago, Ill.
Armour Institute of Technology
*Lawrence, Henry W. .... West Stockbridge, Mass.
University of South Dakota

*Lee, H. Ray .... Bellingham, Wash.
University of Washington
Linderholm, Carl T .... Alamosa, Colo.
Lowenstein, Harry .... Roanoke, Va.
Virginia Polytechnic Institute
Mann, John R. C .... Denver, Colo.
Pomona College
Martin, Armor B. .... Martinsdale, Mont.
Martin, Carl C. .... Martinsdale, Mont.
*Maxwell, Ralph C .... New York City, N. Y.
Mayall, Henry H. .... Denver, Colo.
McBrian, Joseph .... Shawnee, Okla.
McCune, Paul .... Denver, Colo.
University of Cincinnati
McGlone, Edward S .... Denver, Colo.
McGowan, Harold W .... Denver, Colo.
McKenzie, William C. .... Moultrie, Ga.
North Georgia Agricultural College
McKinless, Frank V. .... New York City, N. Y
McWhorter, William S .... Denver, Colo.
*Miller, Elmer D .... Greeley, Colo.
*Min, Edward H. S. .... Denver, Colo.
St. Lewis School, Chefoo, China
Mitchell, George .... Denver, Colo.
State Teachers College
*Mueller, Robert D .... Salamanca, N. Y.
Murch, Thompson H. .... Golden, Colo.
*Nogales, Louis A. .... Cochabamba, Bolivia, S. A.
Ortiz, Salvador .... Guadalajara, Mexico
Parker, Charles O .... Golden, Colo.
Parkinson, Lute J .... Denver, Colo.
Peabody, William A .... Cheyenne, Wyo.
Massachusetts Institute of Technology
U. S. Naval Academy
*Peck, James A. .... Colorado Springs, Colo.
University of Notre Dame
*Peck, Vernon M .... Bridgeport, Conn.
Pena, Aniceto .... Oruro, Bolivia, S. A.
*Peterson, Alex J. .... Grayling, Mich.
Michigan Agricultural College
*Price, Bailey E .... Louisville, Ky.
Rankin, Dudley L .... Golden, Colo.
*Rice, Neil H. .... Denver, Colo.
*Robb, Andrew B. .... New Britain, Conn.
Robineau, Maurice H .... Syracuse, N. Y.
Cornell University

Rolands, Hugo....................................Miami, Fla.
Rollin, George W. .... New York City, N. Y.
Ekaterinoslav Institute
Columbia University
Roper, Joseph S. .... Alamosa, Colo.
University of Colorado
*Ryan, Joseph A. .... Hartford, Conn.
Carnegie Institute of Technology
*Schwab, Philip A. .... Dawson Springs, Ky.
Georgia Institute of Technology
Sears, Norman E..........................East Dennis, Mass.
Bowdoin College
*Selvidge, John V................................Denver, Colo.
Sheriger, Paul M. .... Staatsburg, N. Y.
Sistermans, Frank .... New York City, N. Y.
University of Texas
Kansas State Agricultural College
Slaughter, Thomas N. .... Denver, Colo.
*Smith, Vernon B..........................Morgantown, W. Va.
University of West Virginia
*Starr, Frank J. .... St. Louis, Mo.
Massachusetts Institute of Technology
Stevens, Harry F. .... Breckenridge, Mich.
Stevenson, Philip H. .... Denver, Colo.
University of Pittsburg
Bethany College
*Storms, Frank H. .... Fort Worth, Tex.
University of Texas
*Stortz, Frank J. .... Greeley, Colo.
University of Kansas
Swift, Arthur D.................................Denver, Colo.
*Taylor, G. Keith .... Richmond, Va.
University of Richmond
*Teddlie, John F. .... Ft. Worth, Tex.
Texas Christian University
Tyler, Frederick L. .... Denver, Colo.
University of California
Tyler, Leon G. .... Muskegon Heights, Mich.
*Wideman, Frank L.............................Arvada, Colo.
*Wilson, John H. .... Golden, Colo.
Clarendon College
Southern Methodist University, Texas
Withers, John P. .... Kansas City, Mo.
University of Texas
University of Missouri

*Wong, Albert C. P. .... Hupeh, China
Boone University, China
Worden, John C. .... Denver, Colo.
Yates, John L. .... Holmesburg, Penn.
Young, Yoh-Yin .... Swatow, China
Zatterstrom, Theodore .... Golden, Colo.

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Berry, William J. .... Washington, D. C.
Bukowej, Nicholas .... Denver, Colo.
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Deringer, De Witt C. .... La Junta, Colo.
Downing, Roswell B. .... Oklahoma City, Okla.
University of Oklahoma
Eldridge, Samuel .... Golden, Colo.
Farmer, Ralph T. .... Calipatria, Calif.
Ferguson, Wilbur N. .... Saco, Maine
Foster, Earl F. .... North Platte, Neb.
Francis, Theodore N. .... Denver, Colo.
Frank, Raymond B. .... York, Penn.
South Dakota School of Mines
Frobes, Clarence D. .... Salt Lake City, Utah
University of Colorado

Frobes, Daniel C. .... Salt Lake City, Utah
University of Colorado
Frost, James F. .... Golden, Colo.
Gaines, Harold M. .... Hopkinsville, Ky.
University of Georgia
Vanderbilt University
Galindo, Carlos M. .... Piedras Negras, Coah., Mexico
St. Edward's College
Gallagher, George G. .... Colorado Springs, Colo.
Gardere, John P. .... Marlin, Texas
Virginia Military Institute
Gerhart, Richard R. .... Lancaster, Penn.
Goelzer, Norval P. .... Bloomington, Ill.
Illinois Wesleyan University
Gregory, Joseph N. .... Washington, D. C.
University of Texas
Gump, Leo .... Spokane, Wash.
Hardinger, Sanford C. .... Golden, Colo.
Harris, Harold E. .... Louisville, Colo.
Harrison, Duncan E. .... Golden, Colo.
Heffelman, Charles E. .... Canton, Ohio
Height, Lewis H. G. .... Ocean Grove, N. J.
Hersey, Henry J., Jr. .... Denver, Colo.
University of Denver
Colorado Agricultural College
Columbia University
Hickey, Harold N. .... Creston, Iowa
Columbia College
Hoecker, Frederick W. .... Lincoln, Neb.
University of Nebraska
Holkestad, Harold M. .... Glen Ullin, N. Dak.
University of North Dakota
Hoyt, C. Leroy .... Denver, Colo.
Jecusco, Anthony I. .... Ansonia, Conn.
Jensen, Bertram P. .... Baxter Springs, Kan.
University of Kansas
Jude, William L. .... Meriden, Conn.
Keller, Howard F. .... Fredonia, N. Y.
Hillsdale College
Kleeman, Albert P. .... Golden, Colo.
Lehnertz, Clement A. .... Golden, Colo.
Linburg, Elmer E. .... Montrose, Colo.
Livingston, Harry C. .... Denver, Colo.
Lowndes, Edward R. .... Berkeley, Calif.
U. S. Naval Academy

*MacKelvie, Neil S. .... New York City, N. Y.
Maddock, Edward G.............................Denver, Colo.
Mahood, George P. .... Lynchburg, Va.
McWhorter, Cedric E...........................Denver, Colo.
Messinger, Farrand .... Nutley, N. J.
Rutgers College
Miller, Graham R.............................Trinidad, Colo.
Morris, Harry W...............................Denver, Colo.
Mullen, Donald H. .... Denver, Colo.
Nelson, Robert H.........................Jefferson City, Mo.
O'Neill, James F. .... Leadville, Colo.
O'Toole, Arthur L. .... Newark, N. J.
Rutgers College
Page, Philip W. .... Olney, Ill.
Parker, Ben H...........................Oklahoma City, Okla.
Pasquella, George G...........................Denver, Colo.
Pellish, Maxwell C.............................Denver, Colo.
University of Denver
Petru, Frank J..................................Oak Park, Ill.
Posso, Carlos .... Cali, El Valle, Columbia
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Schooley, Floyd L............................Arvada, Colo.
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Wolfe, Charles E. .... Kenmore, Ohio
Wyner, Alexander S. .... Allerton, Mass.
*Yap, Chu Phay .... Cebu, Cebu, P. I.

SUMMARY

Total enrolment:

Postgraduates	20
Seniors	79
Juniors	122
Sophomores	108
Freshmen	130
Total	459

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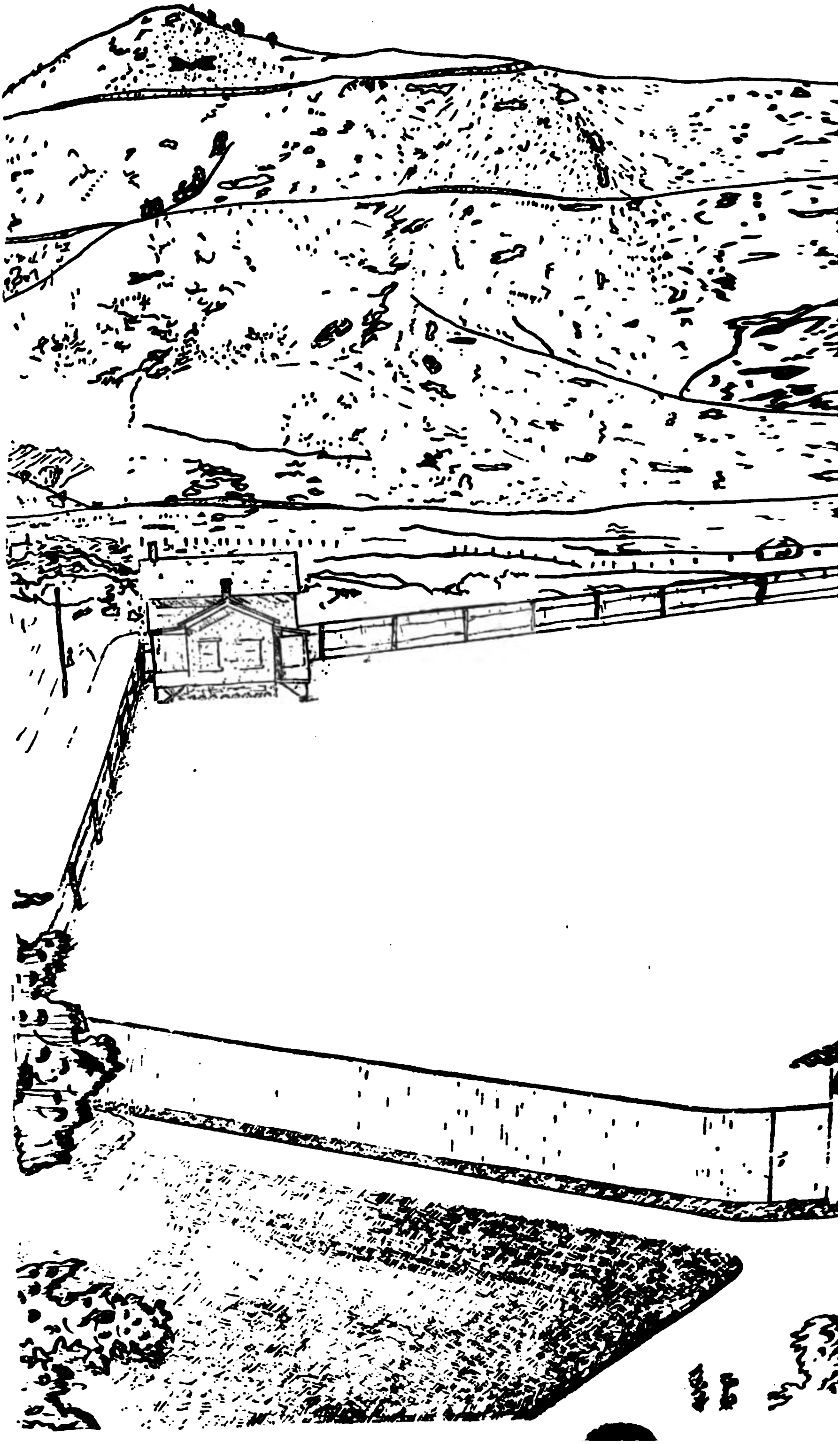

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The Education of a Mining Engineer

BY VICTOR C. ALDERSON,

President, Colorado School of Mines, Golden, Colorado.

(From the Mining Magazine, London, England.)

INTRODUCTION There is no well-defined, no well-established standard of mining engineering education in the United States. Curricula vary in length from three to six years; in content, from a fixed curriculum—the same studies without variation for all students—to one in which a fifth of the work is elective; in character of instruction variations are as great, if not greater. The problem is, therefore, in the language of mathematics, one consisting entirely of variables, that is, with no constants, few or no fixed starting points. In other words, the subject of mining engineering education may be approached from many standpoints and observations made from whatever point of view the writer happens to take. Commentators on the subject may be divided into two groups; one typified by the college professor, and the other by the successful practical engineer. Each has his own point of view and, to his own satisfaction, proves his case, but fails to recognize the point of view or the problem of the other. The engineer in practice is inclined to overemphasize the importance of the particular phase of mining in which he is engaged. If he is a geologist, he expects the young graduate to be well versed in geology and to reason clearly from effect back to cause; otherwise he is apt to condemn the man and the school from which he comes. Also, the mine manager expects the young graduate to be familiar with mining methods and to have had training in "human engineering", the handling of men. Unless the young graduate shows a knowledge and skill in these particular subjects, the mine manager condemns him and his school. In other words, each one expects to get from a school of mines a finished product, adapted to his own particular needs. Rarely does the practicing engineer appreciate the actual condition of the young graduate. In reality, all he should expect is the partly developed material from which a mining engineer can be produced—an embryonic engineer with a good grounding in fundamentals but with only a general fund of details and special applications. The college professor, on the other hand, receives the absolutely raw material, in the substance of a freshman class, generally an unlikely, unpropitious, and heterogenous aggregation. This group he is expected to sift, sort, train, develop, inspire, and from it evolve a "finished product" in four years. No one, in his right mind, who has had intimate acquaintance with a freshman class would hope to accomplish such an impossibility. The most he can do is to eliminate the unfit, inspire the mediocre, and give the best an opportunity to expand and develop into potential material from which a mining engineer may subsequently develop.

FALLACIES a. After an experience of more than thirty years, I am inclined to think that the most glaring fallacy today is the generally unrecognized but actual assumption that a technical school is established merely to carry out a prescribed course of study without due consideration for the material affected, that is, the students themselves. The true ideal of a school of mines should be to train each individual student so that he may make the most of himself, as a man, as a citizen, and as a mining engineer. The personal instruction he receives and the course of study he pursues should be a means to that end and not an end in itself. Too often the operation of a course of study itself is regarded by the faculty as the end to be sought rather than the development of the individual, whereas the individual is of vastly more consequence than any theoretical course of study whatever.

b. The average student does not exist in flesh and blood. There are groups, however, that have certain common characteristics, that is, the indifferent, the lazy, the brilliant, the ambitious, the talented, and the plodder, but there are no two individuals exactly alike in all particulars. This fallacy of the "average student" is the cause of much inefficiency in teaching, because it erects a false goal at which the instructor aims. Instead of trying to reach the average student the teacher should endeavor to reach the individual. In matters of conduct and discipline, the fallacy of the "average student" is still more pronounced, because the offender should always be viewed as "some mother's boy", and judged as such and not as a mere impersonal unit guilty of some transgression.

c. The faculty of a school is composed of a group of individuals—each one a specialist. As an authority in his own subject his word cannot properly be questioned. However, a Board of Trustees selects him and others, specialists like himself in some one subject, to form a faculty. Then this faculty, as a whole, is expected, by some legerdemain, to become expert in management, organization, policies, course of study, finance, and school ideals—all of which subjects are probably foreign to the training, education, and experience of each individual. To be explicit, consider a distinguished metallurgist, an investigator, a prince of the profession; call him to the faculty of a school of mines, expect him, without experience in teaching, without a study of educational practice, ideals, or tendencies, with a slight knowledge of industrial needs, expect him to pass unerringly upon the great moral, ethical, educational, pedagogical, practical, and technical questions covering the ideals of a great school. One is asking for the virtually impossible. Multiply his case by the number in the whole faculty and the average faculty results. To avoid the errors resulting from this fallacy there is needed at the head of higher technical schools men who have made a careful study of general educational methods, the tendencies of the time, the state and needs of the industry, finance, management, administration, human nature, and who are themselves broadly educated, sympathetically inclined towards all subjects of study, and have well balanced judgment and vision; in other words, leaders of men, specialists above specialists. Naturally, such men are rarely found.

d. Another fallacy is the generalization from a particular case. An individual student weak and indifferent, by means of fortuitous circumstances, may occasionally barely pass with the lowest possible grades. He goes out into the engineering world and fails. The school as a whole is blamed and all its graduates are held to be of his calibre. The opposite conclusion is drawn from a graduate of innate ability, above the average. Logically, both conclusions are fallacious. The acid test of any school of mines is, of course, its graduates—not one but many—their character, their training, and their ability to think. The same fallacy as this appears within the college confines. A few students indulge in unseemly orgies; Dame Rumor concludes that all students

do so. A few students "crib" or "cheat"; campus gossip reports that all students are dishonest. It is only fair and just that all ascertainable facts be secured before judgment is passed—no matter what question is under consideration. Such justice is, unfortunately, but rarely accorded.

e. Still another fallacy is to regard the faculty as of one uniform type and the student body as of another uniform type. Too often writers refer to a student body as if each student were exactly like every other student. This is by no means true. As individuals they vary widely in moral stamina, in preliminary training, in mental ability, in energy, in power of concentration, in clear thinking, in previous home training, in environment, and in ambition. It is also assumed that a faculty consists only of high minded men, devoted to their work, self sacrificing, patient, and long suffering. Although this is generally true, yet some black sheep do slip in. On the whole, if we exclude the extremes of the very rich and the very poor, the genius and the dullard, both faculty and students represent fairly well a cross section of average society with all the varied elements represented. Each should be analyzed as such.

f. Another fallacy is that a faculty can prescribe a single course of study that is best, without any exceptions whatever, for all students and will best equip each and every young man for his life's work. This, on the face of it, seems reasonable and is frequently accepted as final. Why not? The members of the faculty are older, more experienced. They know better than the undergraduate what he should study. The case seems simple; can anything more be said? Certainly. Analyze the situation. The entering freshman class, let us say, numbers a hundred men. All that the faculty knows about these men at the start is contained in a brief statistical record, on a single sheet of paper, with perhaps a few formal examination papers. Nothing truly definite is known of each man's character, ambitions, home environment, social connection, or real mental ability. The student is then put through the regular course of study. With rare exceptions professor and student seldom meet outside of the lecture room. Few, indeed, are the cases, especially in the larger institutions, where professor and student get close together and become well acquainted. The single course is pursued throughout the four years with no attention whatever paid to the natural talents, the taste, or the aptitude of the individual student. He must study the subjects laid down by the faculty; whether the subject is the fad of an over zealous professor or one of fundamental importance makes no difference. The student has no choice. He must take it or get out. It may be said in rejoinder that many successful engineers have resulted from such training. Admittedly so. It has still to be shown that they were successful because of the rigid course and not in spite of it. I have had experience with many teachers and students and have yet to meet a faculty that, as a whole, possesses such unfailing good judgment, prophetic vision, deep insight into human character, and omniscience that it can prescribe unfailingly every hour of a student's time for four years and prepare him unqualifiedly for his life's work. There are too many shifting, variable, and uncertain elements involved in this problem of human nature to make its correct solution possible in all cases. Yet some faculties delude themselves into thinking that they can and believe that they are doing it successfully.

THE CONTENT OF THE PRESENT DAY CURRICULUM A most thorough investigation of the present curricula of mining schools in the United States was made recently by a committee of the Mining and Metallurgical Society of America and published as Bulletin 150 of the Society. The committee consisted of three eminent engineers, A. H. Rogers, L. C. Graton, and H. A. Guess. Their report is illuminating in that it shows an almost unbelievable variation in both the theory and practice of what should really be

embodied in a mining engineering curriculum. The curricula of twenty-four mining schools were examined, representing all classes of schools, that is, departments of state supported and private universities, endowed private detached, and state supported detached schools. The following table gives the results of their investigations of the maximum, the minimum, and the average time, on a percentage basis, given to the various subjects taught:

	Maximum	Minimum	Average
Mathematics	16.8 per cent	6.1 per cent	10.5 per cent
Physics and mechanics	13.2	4.0	9.2
Mechanical drawing	8.6	2.8	4.6
Chemistry	15.7	7.3	11.0
Geology and mineralogy	17.7	4.3	12.5
Surveying and mapping	7.4	1.0	3.8
Civil, mechanical and electrical engineering	17.9	7.1	11.3
Mining engineering	19.1	4.4	11.1
Metallurgy and ore dressing	18.4	4.4	10.9

The astounding revelation from this table is the utter absence of unity, coherence, or fixed ideals. The wide variation between the maximum and minimum time required in the same subject in different schools suggests either a lack of appreciation, a fanatical zeal, or a wide difference of honest opinion. Why should one school of mines require less than five per cent of a student's time in geology and a neighboring school require more than seventeen per cent? Also, why is one group of mining engineering students so brilliant that with only 6.1 per cent of their time given to mathematics they can succeed, whereas another group, presumably similar in all respects, must devote 16.8 per cent of their time to the same subject? Finally, how can students of a school of mines that makes any pretense whatever to a high technical mining standard succeed with less than five per cent of their time devoted to mining, or to metallurgy and ore dressing? These pertinent questions have not as yet received a satisfactory answer. In only nine schools is thesis work required for graduation, even though the ability to meet and solve new problems is a prime requisite for a mining engineer. Of the twenty-four mining schools examined, fifteen have curricula in which the studies are definitely prescribed throughout for all students: eight allow electives in amount from 1.3 to 9 per cent of the time of the curriculum. One school, the Colorado School of Mines, allows 20.4 per cent of electives. It may be a significant fact to notice that this school has the largest attendance of any mining school in the United States. Over zealous advisers urge the inclusion, in the mining school curriculum, of modern languages, economics, literature, history, and a long list of cultural studies. Calculation shows that to include all the varied subjects thus designated into one single required curriculum would require an extension of the four year course to one covering a quarter of a century. Such selfappointed critics never have come into personal contact with the raw, unbaked material that presents itself each year to the mining schools for education and training. A very large number of students elect a technical course in general, or a mining course in particular, because of their natural aversion to language and literary studies, their ineptitude for strictly cultural subjects, and their natural fondness for scientific studies with their direct application. They will do their plane surveying on Saturdays, or holidays, without being urged and with keen delight. They will work even all night in the assay laboratory. It is exceedingly questionable how much cultural study should be required in our ordinary four year curriculum in schools supported by general taxation. A serious attempt to require as much literary and cultural study from our body of mining students as zealous advocates advise, would require an intellectual force

pump in every class room. It is eminently proper for a university, privately endowed, to organize a post graduate school and to require two years of previous general cultural training. Such a plan meets the needs of a small class of selected students and will raise the general standard, but would be fatal to the success of the standard four year curriculum in our numerous publicly supported technical or mining schools.

ANALYSIS OF SUBJECTS Few writers take the trouble to analyze the varied qualities a mining engineer should possess beyond one grouping of technical and another of cultural elements. Such a division is by no means complete. Every young man inherits certain mental, physical, and moral traits. These may be modified or intensified by his college training, his environment, and precept from his elders. However, they are a part of his general makeup and must be considered in any scheme of training. Politically, we all may be born equal, but there the parallelism ends. One man has a large physical frame, has initiative, resourcefulness, and natural leadership of men. Why should he, beyond receiving a basal training in drawing, be required to spend long hours over a drafting board when he never can make a skilled draftsman of himself? His success lies in a widely different field. He is destined to be the superintendent or the manager. Another man is the careful methodical student, the laboratory investigator, the strictly indoor scientific man to solve intricate chemical or metallurgical problems. Beyond the fundamentals of geology, why should he, for example, be required to go deeply into the subject of the genesis of ore deposits? He is destined to be a research metallurgist or chemist. Why spoil a good chemist to make an indifferent geologist, a weak executive, or a poor draftsman? There is also a group of personal characteristics desirable for any man to have; personal honor, integrity, reliability, and similar traits. These traits are acquired more by example and by personal contact with the better class of men than by didactic teaching. The third group of subjects, the technical and formal, form the backbone of any technical course. In the arrangement of these, a single track curriculum assumes too much conceit and dogmatism on the part of the faculty, too little regard for the native talents of the individuals, and too much assumption of what each young man's future is to be. Furthermore, too great detail in the subjects taught may also be fatal. The safe middle course is to emphasize and insist upon a thorough grasp of the fundamentals of physics, chemistry, and mathematics, including descriptive geometry, as a foundation for all good engineering practice. If these subjects are thoroughly mastered, variation in the later subjects becomes of minor importance. The most essential element of all, overshadowing every other phase of the subject, is to teach a young man to observe closely, to think clearly, logically, and accurately. If this is done, a young man, irrespective of whether he has studied under Prof. A—or Prof. B—, regardless of whether his time has been spent in the assay laboratory, the mineralogical collection, in the drafting room, or in the chemical laboratory, has received an education, because the essential difference between the uneducated and the educated is the ability to think.

THINKING Inductive reasoning, that which advances our knowledge, consists of four steps; a. careful and correct observation of facts; b. the formation of a tentative generalization or working hypothesis to explain the facts; c. prediction of the unknown, under the assumption that the generalization is correct; d. verification. This complete cycle can, of course, be exercised only by the original scientific investigator, but the spirit of it is adopted by every effective teacher in training a student in accurate observation and clear thinking. For pure exposition, no better form can be used than the method of the old Aristotelian logic, namely, from the general to the particular, from the

indefinite to the concrete, from the whole to the parts. The human mind naturally functions in this way. Read again Goldsmith's "Deserted Village". Note his first verse,

"Sweet Auburn! loveliest village of the plain"

which is a perfectly general statement followed by details in the description of the village. Then minor wholes are treated in the same way as

"There, where a few torn shrubs the place disclose,
The village preacher's modest mansion rose", and again,

"Beside yon straggling fence that skirts the way,
With blossom'd furze unprofitably gay,
There, in his noisy mansion, skilled to rule,
The village master taught his little school".

A logical analysis shows that Goldsmith, though by no means a logician or a teacher himself, hit upon a perfect construction for "The Deserted Village", the construction which moves from the whole to the particular parts. Inasmuch as this procedure is in harmony with the orderly working of the human mind, the reader easily receives a perfect mental picture. The same procedure is used effectively by descriptive writers like Washington Irving or Stevenson. Aside from pure literature the same principle applies in editorial work and newspaper "stories". The editor demands that the first sentence shall embody the whole story. Headlines and captions are good illustrations of this idea. A well constructed paragraph, on any subject, requires a topic sentence at the beginning followed by details, and a concluding sentence that closes the subject. A well constructed sermon, a carefully prepared lecture, or an effective argument, is necessarily constructed on this plan. A good teacher arranges his course as a whole, and each division or lecture on this plan, because it follows the direct avenue to the human mind, is the line of least resistance which results in efficient teaching. Aside from personally effective characteristics and a thorough knowledge of his subject, a teacher should have a good understanding of psychology in its pedagogical aspect. Not that he should teach psychology, but that all of his work with students should be based upon correct psychological principles. Specifically his lectures, his demonstrations, his explanations should always be based upon the logical plan of going from the general to the particular. Many a teacher has failed because he did not realize the transcendent importance of this logical principle.

TYPES OF STUDENTS The most numerous of any type of student that has come under my observation is the strong, sturdy, aggressive, independent young American, ready on call to lead a football team to victory, preside at a class meeting, answer the call for helpers on occasion of a great national calamity, enlist for the war, gather a group of workmen, go into the hills, establish a camp and develop a mining prospect, or join an expedition to seek for oil in the Arctic regions or the wilds of Africa. These young Americans are the bone and sinew of the next generation. Those of us who enjoy the delight of associating with such young men, as guide, leader, or elder-brother, do not get enthusiastic over the well meaning but misguided advice of outsiders that they would become greater men if we forced them to appreciate Browning. No. Success in developing the resources of nature, in advancing the state of civilization, and in making this a better world to live in, has a dignity and character all its own and should not be confused with the culture to be obtained by following a purely literary career. Another type of student has mental characteristics strongly developed. He has the strictly scientific point of view. His habitat is the laboratory. He is a thinker and essentially an indoor man. His success may not be spectacular, he may be known only in technical circles, but his work is eminently efficient. He should be given

the opportunity to train himself to a method of strict scientific thought, accurate observation, and logical reasoning. Without him, mining science could not advance. A third type shows very early a distinct business-like character. His studies are all virtually interesting to him if they bear upon life's activities. He is a student of human nature; he studies men as well as things. He is constantly finding ways in which to earn a little money. He is an all around individual. If he has a fair opportunity, after leaving college, he soon gets into the business side of mining and, later on, becomes an executive. A fourth type is the mentally slow, the man who acquires with difficulty, but is thorough and substantial and has good common sense. He is popularly called the "plodder". There is a niche for him in the mining industry and occasionally he comes to the fore, possibly to the surprise of the unthinking. A fifth type consists of a motley group of the stupid, the misfits, the lazy, and the generally unworthy, who fall by the wayside and are as soon forgotten. A practical test of a mining school is the percentage of good material it can produce from the raw material that comes to it annually as freshmen.

TEACHING vs. LECTURING Many writers on education fail to recognize the difference between mere lecturing and actual, Simon-pure teaching. Mere lecturing, the presentation of facts, even if done in logical order, is not teaching. The youth eats, sleeps, exercises, and develops day by day his physical body. In a parallel way his spiritual, moral, and mental being is slowly developed. For the sake of simplicity, consider only his mental development. This development comes slowly, hour by hour, day by day. The real purpose of the teacher is to establish such a regular plan of work as to aid this development. The substance and not the shadow must be presented. A menu card will not take the place of a substantial meal. The baby crying for milk is not appeased by a milk ticket. As proper food and exercise vary with the physical needs of the individual, so do the mental food and exercise vary. The individual seeking education is faced with a problem of work, work on his own part. He cannot sit idly back, view motion pictures, listen to lectures, fill a notebook with facts, and become educated. He must assimilate the material put before him, make it a part of his mental warp and woof, just as his system assimilates the food he puts into it. Such mental assimilation results only from careful attention, close application, revision, review, concentration, and thought. No subject can be thoroughly assimilated until it has been gone over again and again; till the beginning is viewed in the light of the end; the end in the light of the beginning; and the middle viewed from both ends. The acid test of mastery of a subject consists of three parts: the ability to make a logical outline of it, correct in all details; to condense it all into a few words, and to expand on any detail. Mere presentation of facts by lecturing does not accomplish this, but real teaching does. Every good preacher is part teacher: every good teacher is part preacher. The task of each is not an easy one. The work is wearying and exhausting; that is, to speak figuratively, if the teacher believes that a student should drink from a running brook rather than from a stagnant pool. However, the greatest delight for a teacher is to be associated with a group of ambitious students, seeking to make the most of themselves, and his greatest compensation is to see them succeed in their life work, whatever that may be.

CHARACTER STUDY Mere acquisition of knowledge is not sufficient. It does not develop power. The encyclopedic mind is not for the mining engineer. Ordinary forms of instruction are static; the training of a mining engineer should be dynamic. He should not be told that he is merely in training for life but that he is fighting life's real battle circumscribed, planned, and limited perhaps, yet in embryo living his real life; that he is a generator and not a storage bat-

tery; that wisdom is better than knowledge; that knowledge alone is not the key to success. Judgment of a student should not be based on a mere test of his knowledge, but should consider his potentialities. Study should be made of his character, initiative, executive ability, morale, manners, technical ability, command of English, personality, heredity, ambitions, and prospects. That is, he should be judged as a full man and not as a mere recording machine or phonograph.

BREADTH OF MINING Of all the branches of engineering, mining has the broadest field, requires the widest range of knowledge, and develops the greatest number of human potentialities. The mining engineer may be called upon for ability in drafting, design, geology, chemistry, mechanical, electrical, or civil engineering, besides a knowledge of law, economics, business, and administration. Not that he needs to be an expert in these branches, but at some time in his career he may need more than a mere formal acquaintance with them. In fact, almost any kind of knowledge or skill, even to the homely art of camp cooking, may be a convenience or even a necessity. For this reason, the glaring fallacy of trying to prescribe unfailingly the exact subject, period, and content of every hour of a man's time for four years becomes apparent. At best, the curriculum can be only a resultant of many conflicting forces, with a form and content that will represent opportunities for the individual.

AN OPPORTUNITY It is a mistake for any body of men, even a mining school faculty, to assume that it can judge unerringly of each student's latent talents, his ambitions, his vitality, his vigor, his mentality, his occupation after graduation, or, in brief, his whole future career. In the rarest of rare cases a young man knows exactly what he will do. To outline a course of study for him is simplicity itself. The majority of students are, after graduation, victims of circumstances. For any group of men whatever, even college professors, to claim unfailing judgment in the case of each young graduate is to claim a power to see into the future claimed in ancient times only by the soothsayers and today only by spiritualists, fortune tellers, and their ilk. The present day mining school should be not a mere group of buildings where distinguished scholars teach, but a "great opportunity", where young men may go and find the environment wherein each one can develop his own powers, under the best advice he can obtain from any source whatever, so as to make his own individual life work a success. To quote General Walker's classic phrase a mining school should be "a place where men may work and not where boys may play".

A TWENTIETH CENTURY CURRICULUM Destructive criticism or mere logical analysis that results in no suggestion for improvement is useless and worthy only of the pessimist. The curriculum most likely to give the maximum of good results in the education of a mining engineer is one founded on a basis of a thorough, fundamental knowledge of physics, chemistry, and mathematics. A rigid course in descriptive geometry should be demanded because of its training of the imagination and the art of thinking clearly in three dimensions. These fundamentals should cover the first half, the freshman and sophomore years, of the regular four year course. To these fundamentals should be added mechanical drawing, lettering, surveying, general geology, crystallography, and mineralogy. These courses, absolutely fundamental for any branch of mining engineering, should be required of all students. They form an irreducible minimum. Needless to say these fundamentals should be taught thoroughly not by young inexperienced members of a faculty, but by the best teachers obtainable. During the second half of the curriculum, a student should be allowed to major in that branch which his talents, his innate fondness,

and his judgment dictate to be the one he is best fitted to pursue; for example, practical mining, metallurgy, geology, oil, or chemistry. After choosing a major, a few basal courses should be prescribed. The time remaining should be given to a judicious selection of courses in the other curricula. The degree should be conferred when a man has completed the required work of the freshman and sophomore years, the prescribed work in his chosen group, and sufficient elective hours to meet the number required for a degree.

It may be granted that such a curriculum is based upon the elective principle. That is true, but the fundamental subjects are by no means neglected, nor is too early specialization advocated. Besides, there is the utmost latitude for a student to develop his own latent ability without wasting his time; the brilliant student is not held back by the mediocre or lazy member of his class. The criticism often has come to me seriously from parents, engineers, and thoughtful students, that the pet theories of individual members of a faculty should not be inflicted upon students regardless of the students' innate capabilities. The elective principle first comes into force when a young man selects a mining rather than a law course. After he enters, the question of what he will select is ever before him. He is not one sheep to follow implicitly the sound of the bell. He is a rational human being, expected to carve out his own career. Naturally the value of various subjects are discussed freely among the students, with members of the faculty, with engineers, or with distinguished men who visit the school. The choice of an individual student results from a variety of influences and usually I have found it to be wise. It may be urged that students will select "soft" courses. In a well organized mining school there should be no "soft" courses. Should a member of the faculty stoop to the low trick of trying to gain popularity and prestige by making his course easy he is out of place in a self respecting faculty. The right minded student, intent on getting the best possible preparation for his life's work, does not want "snap" courses. He prefers strong, thorough, comprehensive courses, well taught, with a high degree of attainment demanded. It is a pleasure to record, from my personal experience, that the well intentioned young American student wants high grade teaching, desires only a fair chance, and craves an opportunity to develop himself; his criticism of a poor teacher is merciless. To-day the mining school that offers high grade instruction, "stiff" courses, and thorough teaching, demands effective work from the students, gives the best opportunity for self development, and presents high ideals is the school sought by the best type of young Americans.

CONCLUSION The Great War caused destruction of property to an extent never before witnessed in the history of the world. This property must all be rebuilt or renewed. The next decade will be distinctly an engineering age. The world needs regeneration, rebuilding. There never has been such a demand for engineers as will develop in the present decade. The mining school has its work to do. If this is done well, the school must have certain well defined characteristics.

(a) A school of mines must be democratic in tone, with a fair and individual chance given to each and every man.

(b) It must be essentially an "opportunity" where the individual may develop, to the highest degree, his own innate capabilities.

(c) It should be a "place where men may work and not where boys may play".

(d) It should exert the utmost effort by example and environments to develop the morale, the character, and the finer elements of manhood.

(e) It should limit the required subjects of study to the fundamentals and a wide latitude of electives allowed to permit individual development.

In fine, the function of a school of mines should be to develop embryonic engineers, possessed of the fundamentals, good citizens, and all around substantial members of society.

The recent international conference on the limitations of armaments was influenced by the high ideals of Secretary of State Hughes and President Harding. It was an epoch making event in the history of civilization. It gave an enduring phrase to all human endeavor whether in the field of politics, law, medicine, business, manual labor, or education, a phrase that may well be remembered by every one engaged in any occupation and especially with those who are guiding the young to a useful life and have the responsibility of molding the character and habits of the next generation. President Harding's fruitful phrase, tersely put, was that we should all be "more concerned with living to the fulfillment of God's high intent".

Volume Seventeen Number Three

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COMMERCIAL OIL SHALE---
WHAT IS IT?

VICTOR C. ALDERSON,

President, Colorado School of Mines

A LEGAL CONTEST

Articles on oil shale that have been written thus far may be divided into three classes. a. Technical articles devoted chiefly to the chemistry of retorting and refining; b. Informative articles devoted to a survey of the progress that is being made; and c. Propaganda to sell stock. In the early stages of any new industrial enterprise of wide scope, errors of judgment are sure to be made, fake promotions will inevitably appear, and misstatements become current. Rarely does it happen that opportunity is given to secure data submitted virtually to a court of justice, given by competent experts under oath, subject to cross-examination, and involving large financial considerations. Such an opportunity recently occurred before the Register of the Government Land Office at Glenwood Springs, Colo., Jan. 27 and 28, 1922. The Government brought suit to cancel certain locations of oil shale land in the Debeque district on the ground that the land was not mineral and not valuable for oil shale, that the locations were not made according to law, and that the annual assessment was not legally performed. The mining law requires that, to make a valid placer location, the lands included in the location must be valuable chiefly for the minerals for which the land is located. The case is known as United States, contestant, versus Bailey, Krushnic et al, contestees, and Ernest Wight, transferee. It appeared that the transferee had purchased the interests of the contestees prior to the commencement of the suit, and the expert witnesses who were called, aside from those called by the Government, were called by the transferee. The Government was represented by R. R. Duncan, as its attorney, and the transferee was represented by Robert D. Hawley as his attorney.

GOVERNMENT REGULATIONS FOR THE CLASSIFICATION OF OIL SHALE LANDS.

The transferee submitted the following rules adopted by the Lands Classification Board of the U. S. G. S., under the supervision of the Chief Geologist, April 5, 1916. Under these rules certain land was classified as oil shale placer subject to entry. The Government officials present at the trial did not know that such rules were in existence.

In the following regulations a yield by distillation of *one gallon of crude oil per short ton of rock is considered equivalent to a yield by distillation of 50 barrels (42 gallons each) of crude oil per acre-foot of rock.*

I. Land shall be classified as oil shale (mineral) land if it contains *1500 or more barrels of crude oil per acre in beds of rock not less than one foot thick yielding by distillation not less than 15 gallons of crude oil per ton* and lying at a depth below the surface not greater than one-half the difference between 1500 and the number of barrels of crude oil per acre:

	1 foot	2 feet	3 feet	4 feet	5 feet	6 feet
Gallons 15	750	S 1500	375 2250	750 3000	1125 3750	1500 4500
20	S 18" 1500 1000	250 2000	750 3000	1250 4000	1750 5000	2200 6000
25	S 14.4" 1500 1250	500 2500	1125 3750	1750 5000	2375 6250	3000 7500
30	S 1500	750 3000	1500 4500	2250 6000	3000 7500	3750 9000
35	125 1750	1000 3500	1875 5250	2750 7000	3675 8750	4500 10500
40	250 2000	1250 4000	2250 6000	3250 8000	4250 10000	5000 11500 (38.66 Gal.) 12000
45	375 2250	1500 4500	2625 6750	3750 9000	4875 11250	13500
50	500 2500	1750 5000	3000 7500	4250 10000	11500 (46 Gal.) 5000 12500	15000
55	625 2750	2000 5500	3375 8250	4750 11000	13750	16500
60	750 3000	2250 6000	3750 9000	5000 11500 (57.5 Gal.) 12000	15000	18000

Provided, That no bed shall be considered as more than 6 feet in thickness or as yielding more than 60 gallons of crude oil per ton and no land shall be considered as containing more than 11,500 barrels of crude oil per acre:

Provided further, That if the bed lies below the depth limit provided in this section but within a horizontal distance from the surface not exceeding 10 times the depth limit, or if its horizontal distance from the foot of a possible shaft (not deeper than the depth limit) plus 7.5 times the depth of the shaft does not exceed ten times the depth limit, the land shall be classified as oil shale land:

Provided further, That the depth limit shall be computed for each individual bed, except that where two or more beds occur in such relations that they may be mined from the same opening the depth limit may be determined on the group as a unit, being fixed at the center of weight of the group, no bed below the depth limit thus determined being considered.

II. Land shall also be classified as oil shale land if it contains at or so near the surface as to be minable by open cut or stripping methods rock not less than 6 inches thick yielding not less than 15 gallons of crude oil per ton and having a total yield not less than 750 barrels per acre:

Provided, That no bed shall be considered as more than 6 feet in thickness.

TABLE FOR DETERMINATIONS

The accompanying table was also submitted to illustrate the regulations and to aid in the rapid determination of commercial oil shale. The top row indicates the thickness of the deposit in feet; the left hand column the yield in gallons per ton; the figures in the bottom of each square the yield per acre; and the upper figures the maximum depth permissible. That is, a four foot bed, yielding 35 gallons to the ton has a capacity of 7,000 barrels of oil to the acre and, if not deeper than 2,750 feet from the surface, would be classified as oil shale placer, subject to entry. Also, a two foot bed at the surface yielding 15 gallons to the ton and 1,500 barrels to the acre foot would also be classified as oil shale land.

GOVERNMENT WITNESSES

Much of the testimony offered was technical, detailed, and interesting only to those financially interested. However, the paucity of the facilities given the government officials to judge properly the value of oil shale land was noticeable. C. L. Duer, Mineral Examiner for the Government Land Office, stated that he had made no test of oil content and depended upon common report, e. g.

Question. Does this shale bed, in your opinion, applying the rules for classification with which you are familiar, contain oil bearing shale in sufficient quantities to justify expenditure of money for its extraction, with a view to opening a mine?

Answer. *Well, I have never tested this shale for the oil content. It is commonly regarded throughout the oil shale region as being of no value.*
Again:

Question. Haven't you any *personal knowledge of the quantity of oil that particular stratum may contain?*

Answer. No, sir.
Or again:

Question. *In what way do you ascertain* whether a particular piece of shale rock is oil bearing or not?

Answer. *By the appearance of it*, color, specific gravity, weight.

* * * * * * * * * *

Question. *But you never have made any such tests at all.*

Answer. *Only in the crudest way*, to see whether shale would burn or whether you could get a test for oil.

Another Mineral Land Examiner, O. J. Berry, testified as follows:

Question. *What actual experience have you had* in determining the various grades of shale as to its oil content?

Answer. I wish to say that *I have never made any shale analyses* and it is just by examining the shale and also comparing it with other shales with which I have been more or less familiar and comparing the specific gravities and the color and other physical appearances.

Q. In view of that fact, how do you distinguish, Mr. Berry, between those strata which are of commercial value and those which are not?

A. Well, I thought I had mentioned that in detail, and in my opinion, it depends solely on the thickness of the beds; and my reason for giving this answer is it is similar to the mining of coal.

* * * * * * * * * *

Q. But you admit that the opinion is that formed upon the speculative basis, that there have not been any commercial operations so far, and it is probable that the first commercial operations might be on a thinner vein or thinner strata?

A. It is possible that they may find minerals in these oil shale, which in my opinion, are not there. *I have never made any tests* to know that these minerals are not there, and *I have been told by several parties that they are there.* If that is true, perhaps the entire Green River formation may some day be worked; but, in my opinion, that is an erroneous statement to make.

Q. But as mining industries have developed, the richer bodies have always been worked first, have they not, Mr. Berry, and then those that were leaner on down?

A. There is no question but what the richer shales will be worked first, and there is *sufficient shale proven to exist in this area to run for a good many years*, even after they start the development of it.

* * * * * * * * * *

Q. You never conducted in behalf of the Government any experiments by the use of the drill or otherwise to see what was there, did you, below the Wasatch?

A. No, sir. *I have never conducted any drilling operations whatever.*

The transferee of the contestees, in answer, submitted evidence by technical men which, for thoroughness of preparation, depth of knowledge, and comprehension of the problem was in striking contrast to the evidence submitted by the Government. Albert R. Crossfield, chemist, testified as follows:

Q. How many samples would you say, approximately, that you have tested of the shales of Garfield County?

A. *I have made, or had made under my personal supervision, probably 6000 tests of oil shales, covering some 900 samples.*

Q. What were the results of your tests of the shales in this area and the shales which are found on these claims in question, as to production of oil, based upon the production in gallons per ton; how did those tests vary, and what were the limits you would define?

A. I made a superficial qualitative examination of the shales as they are exposed from the Wasatch contact at an elevation of 6,000 feet to an elevation of approximately 7,300. I made certain qualitative tests of those shales that would indicate that all of them would have some oil, or material from which oil could be produced by destructive distillation, and some strata of shale that would indicate a *gallonage of as high as 40 to 45 gallons per ton.*

* * * * * * * * * *

Q. Have you any data here to give us the results of your qualitative analyses and elevations at which you found them?

A. At 6,400 feet there is 18 inches, approximately, of shale that will go 12 gallons to the ton. At various elevations up to 7,100 feet there are other strata that will go as high as 20 to 40 gallons a ton, perhaps as high as 45. At 7,100 feet there is a stratum that will yield probably 35 gallons; at 7,200 feet, approximately, there is a stratum that will yield 25 gallons, another that will go as high as 35.

Q. Did there appear to be any relation in the increase in the quantity of oil obtained and the increase in your distance up from sea level?

A. That is a difficult question to answer without going further into the matter of considering the whole deposition there. *The rich and lean strata alternate,* not definitely, but there may be a rich stratum at low elevation, there may be a very lean one at a high elevation. There will be rich and lean in between those two.

Q. Well, as a general statement, would it be true to say that the richness of the shale increases as you ascend and get to higher elevation along this shale escarpment?

A. It is reasonable to say that the shales of the Green River formation increase in a general way from the bottom upwards until the approximate center of the formation is reached, at which point they begin to decrease again.

Q. Would you say that that, too, was uniform in its thickness and in the quality of the shale with respect to its oil content all through this area?

A. It is my opinion that *the shale deposits are very uniform throughout the whole center of the deposits.*

Q. From what facts in your knowledge and on what particular investigations of that particular feature do you base that conclusion, that the shale is uniform as to the oil content?

A. *I have made very thorough examinations of the same stratum scattered over wide areas of land and find that they do not vary to any appreciable degree, or to a very slight extent.*

Q. Now you referred to commercial shale. What do you mean by that?

A. The record will show that I used the term commercial shale. For the purposes of this examination, *I consider any shale that occurs above the Wasatch contact valuable for the commercial development of the oil shale deposits.*

Q. In your judgment then, and opinion as a mining man, any land that contains oil bearing shale is mineral in character?

A. My opinion as a chemist is that any land containing material from which *oil can be produced by destructive distillation, material commonly called oil shale, should be considered as mineral land.*

Q. Would you advise anybody to work or attempt to mine and manufacture oil shale containing fifteen gallons per ton at the present time?

A. *I would advise nobody to invest a large amount of money in any oil shale deposits without a thorough research investigation.*

Q. Would it make any difference as to the oil content, what your advice would be?

A Naturally. The richer the oil shale is the better I would advise them to make an examination of it.

Q. Well, would you advise anyone to explore with a view to establishing a plant and investing money to mine and manufacture oil shale, where the oil shale ran at 50 gallons per ton?

A. *I would advise anybody that contemplated building a plant for the extraction of the oil to make a thorough examination of all the property, both in extent and in elevation.*

Roderick D. Burnham, mining engineer, and geologist, testified as follows:

Any mining company merely owning the upper high-grade streak of shale, the most prominent one in that district and not owning any land below that, would be forced to operate at a great disadvantage due to the steepness of the slopes. From that high grade streak down to the bottom of the mountain there is no place on which you could build the ordinary mining works, such as machine shops, dump yards and the numerous other buildings which are necessary for a large low grade mine to have. It is therefore necessary that you have enough land at the foot of that slope on which those works can be built. Aside from that, you have got to have more or less protection for your men. As everybody knows who is familiar with the shales in this country, in the winter time especially, rocks are continually coming down from the high escarpment, due to the freezing and thawing of the ice and snow in the crevices. It, therefore, becomes very important to protect your men from this condition, and you have got to get far enough away so that those rocks will not cause damage. When you consider that the shale game, in order to be operated successfully, will have to be done on a very large scale, as the profit per ton will be small, it becomes necessary to use a large number of men. *As an approximate figure your total payroll will probably represent five tons to the man; in other words, a property producing 25,000 tons a day will have to operate with 5,000 men.* The largest portion of those men have got to be taken from the foot of that slope up to the ledges that are being worked. After you get them underground you have got to have a continuous supply of material in the way of rails, ties, timber, and mining machinery constantly going in to them. Because of these conditions it is very apparent that you have got to have considerable room to put that stuff at the foot of the slope nearest to the entries that you intend to use it in. After you have considered that condition, you have also got to realize that every ton you take out leaves a space of about eighteen cubic feet; that after you have taken it out and run it through retorts that eighteen cubic feet is increased to thirty-five cubic feet, or nearly double its volume. This spent shale has got to be taken care of in some way. Therefore, *dumping grounds for spent shale become of prime importance in rounding up a complete mining program.*

* * * * * * * * * *

Q. In these recommendations which you have made, did you take into consideration any other stratum of shale than the stratum which you have designated as high grade?

A. Yes, sir. There are numerous other strata underlying the high grade streak which I feel sure at some time in the future will be operated. The fact that they may seem low grade to us at the present time is no reason to say that they will not be operated.

Q. You feel that they will be operated?

A. I do. They will be operated in conjunction with other high grade streaks, which will raise your oil content to such a point that you can mine it economically. For instance, the six-inch streak of 40 gallon stuff added to a three foot streak, we will say, of fifteen gallon stuff, will probably show a profit even if mined individually. In foreign countries they are mining on streaks down to two feet in thickness, and in some cases as low as eight gallons per ton. In that case they are mined with their additional high grade streaks and the total content brought up, but in many instances their total heads do not exceed 14 to 17 gallons per ton.

Q. Shales of that character are being mined at a profit?

A. Yes, sir. In 1918 the annual report or financial statement of the Pumpherston company in Scotland showed dividends of forty per cent on their common stock and six per cent on their preferred, and they are operating on a low grade shale and mining at depths from 600 to 1200 feet.

* * * * * * * * * *

Q. I will ask you if you have made a careful study of the reports and literature available pertaining to the oil shale industry in Scotland?

A. Yes, sir.

Q. And what would you say as to the comparison of the mining conditions on the properties of the Pumpherston company which you have mentioned, and the mining conditions which will necessarily be encountered upon the properties now under consideration?

A. *I would say that our properties in Garfield County, Colorado, are fifty per cent better.*

* * * * * * * * * *

Q. *In your opinion, upon what basic fact will depend the time when the oil shale in Colorado will be operated on a commercial basis?*

A. I don't think that time will have anything specially to do with the price of oil. We are going to go into the oil shale game *when the curve of consumption of the world approaches the curve of production,* and when those cross and we are consuming more than we are producing, *we are going to start to operate the shales irrespective of the price of oil at that time.*

Q. Is it possible to say with any definiteness that that time will come this year or next year or three years from now?

A. No, *it is dependent entirely upon the world conditions,* as I see it.

Q. Do you think that this time is far away or that it will come in the comparatively near future?

A. *I feel that it will come within the comparatively near future.*

Q. Is there any doubt in your mind that the Green River formation, without considering any particular stratum, will in the course of time become the source of the supply of America?

A. I feel that the time will come when it will contribute very largely to the oil produced in America.

Q. It is your opinion that these lower strata in the Green River series, which have been discussed in this controversy, will become a part of a profitable commercial industry?

A. Yes, sir.

Q. Then considering these facts, I will ask you what part or portion of the Green River series you consider at this time to be commercial shales, as that term has been used here?

A. I would consider *nearly the whole Green River series as being valuable for oil shale*, with the exception perhaps of the very lowest portion which may have some sandstones in it and which will be barren; but I feel that from practically 200 feet above the red beds the rest of the series can be considered as valuable for oil shale.

* * * * * * * * * *

Q. In your examination of the grounds have you seen any indication of any other minerals other than oil shale there?

A. No, sir.

* * * * * * * * * *

Q. Now, you made a comparison between the conditions in Scotland and in Colorado in the particular field in question. Are the topographical features and all the elements that enter into the mining operations such that you can make a fair comparison between the shale industry in Scotland and the industry as composed in Colorado?

A. Well, I think we have mining conditions, when we get started and can do a certain amount of experimental work, that *we can mine cheaper than they can mine in Scotland*, even taking into consideration that our labor will probably always be higher priced labor than it is in Scotland, because it is always cheaper to move tonnage by gravity than it is to have to move it up against gravity by hoisting.

Q. But that, so far, is hypothetical and there has been no demonstration as to whether or not that can be done?

A. There have been all kinds of demonstrations on this type of work in other mines.

Q. I mean here in Colorado?

A. Not here.

Q. Do you know whether or not there may not be something in the very composition of the material, the oil shale, that might require a different process, in such a way that the Scottish process if used here would not produce the same results?

A. You mean in the retorting or the mining?

Q. In the retorting.

A. I think that *here is the whole idea*. When it comes to comparing Scottish retorting and American retorting, as you know, the Scottish people, most European people, are content to take out a small amount and they are not specially worried about the length of time that it takes to get that out, the chief reason for this being that the labor is so cheap and costs so little that time is not an element. *In America*,

with high priced labor and high priced materials, and the driving and the force that the Americans put into everything, we are constantly trying to do the same thing in half the length of time as the other fellow. When we started the shale game, the American men immediately conceived getting all the oil out of shale, and instead of taking twelve or eighteen hours to do it, a lot of them are trying to do it in twelve or eighteen minutes. The consequence is, a fellow, when this thing is finally worked out, will have a process not necessarily identical with the Scottish, although there may be many principles that are similar, but it will be very much more rapid.

* * * * * * * * * *

Q. In your opinion, is the shale industry to be one involving rich values and operated as a small proposition, or is it to be a low grade mining proposition operated on a large scale?

A. I feel that *it has absolutely got to be operated in a very large way,* handling a very large tonnage per day, in order to make any profit. I do not feel that small operations will have any chance of paying out or making any money on their investment.

* * * * * * * * * *

Q. Mr. Burnham, I will ask you whether in your opinion the future of the oil shale industry is dependent upon the working out of the problems in connection with the mining and treating of the shales, or whether it is dependent in a much larger scale upon marketing conditions and the demand for oil?

A. I would say that that was a fifty-fifty question. If you have not got marketing facilities and cannot come into competition with other companies marketing oil, you are not in a position to make money in the shale game, even though you do produce oil.

Q. Well, this is the point I have in mind: *Is there any doubt in your mind that when the time comes that there is a demand for this oil that the problems connected with the mining and treating of the shales will be worked out satisfactorily?*

A. *Absolutely no doubt at all.*

Q. Those problems have been worked out satisfactorily in other countries where the shales are being operated on a commercial basis, have they not?

A. Yes, sir.

* * * * * * * * * *

William C. Russell, a mining engineer of wide experience and high professional standing, testified:

Q. What in your opinion, Mr. Russell, will be the principal problems to be met in connection with the operation of this property, so far as the mining of shale is concerned?

A. The proper placing of the equipment and appurtenances used in mining operations and the securing of the necessary dump ground for the waste and the spent shale.

* * * * * * * * * *

Q. Are the specific beds that you recount in the lower member of the Green River formation, as exposed on the land in question, all workable beds?

A. From a mining and mechanical standpoint?

Q. Yes, sir.

A. They are. However, I wish to qualify the statement which I made preceding the statement which I made now and state that *all the beds of shale in the Green River series are workable from a mining and mechanical standpoint, as such.*

Q. You mean by that that it is possible to extract the ore?

A. It is possible to extract the rock; yes, sir.

Q. But is it practicable or probable that all the strata encountered in the lower member of the Green River formation on the land in question is workable?

A. Not for some time to come, at least.

Q. And would such beds be considered until richer and more valuable beds had been mined?

A. That would depend somewhat upon the thickness and value of those lower beds and upon the possible use that you might have for the surface where they crop.

Q. In other words, in considering that, you would consider the adjuncts to mining values, and the plant site values, in determining that?

A. No, I was thinking possibly you would not want to cover up an exposed bed with your debris or your spent shale and then have to go through that to mine your lower stratum. If you were mining an upper stratum and were dumping down upon the lower stratum, it might be advantageous for you to take out the lower stratum to be used in connection with the other stratum. There might be such a possibility.

Q. Is there any bed or stratum of oil shale that you found on the land in controversy here, in the lower member of the Green River formation, of equal value to work as beds higher up?

A. No, sir.

Q. Is there any bed that you would consider worth prospecting and mining, of itself, on the lands in question in the lower member of the Green River formation?

A. Not in itself, if it were entirely isolated from the rest of the property.

Q. Isolated and considered apart from any other stratum of shale?

A. Yes, sir.

* * * * * * * * * *

Q. Have you found oil exposures by personal observation on each and every claim that you designated as chiefly valuable for oil shale?

A. By both close examination and long-distance observation I saw shale over the whole area above the Wasatch, and one getting into a commanding position can see that oil shale.

Q. He can see the stratum at some points where it can be visible to the eye, then from that he infers from his knowledge of geological conditions that they will exist throughout the field along that cropping?

A. Yes, sir.

* * * * * * * * * *

Dean E. Winchester, formerly with the U. S. Geological Survey, who did the first field work on the oil shales for the government and wrote the first government reports on the district, testified:

Q. What part did you have, if any, in connection with the work of examining the lands in northwestern Colorado, northeastern Utah, and southwestern Wyoming, with a view to selecting those valuable for oil shales and so classifying them for the Government?

A. In February, 1914, the work in connection with the oil shales of the United States was put under my direction. Beginning in June of the same year, field examinations of Colorado, Utah, and Wyoming were begun. At the close of the second field season's work the question of the government's attitude towards shale land was brought up, in a similar manner as has been its attitude towards coal lands, and I was called into consultation with what is known as the Land Classification Board of the Geological Survey, which has made and does make classifications of lands as to their mineral properties, whether it be oil, coal, minerals of the metallic group, or any other mineral products. In those meetings of that board the chief geologist of the Survey and the Director of the Survey, and all who could have information which might be of use to arrive at a conclusion as to the government's policy with reference to lands containing these shales, were all present, and during that time *a policy was drawn up, upon which was based the classification of lands, either as shale land or as non-shale land.*

Q. Have you a set of those regulations with you?

A. There have been copies brought here, I haven't them in my pocket; I think they are on hand.

Q. I will ask you to examine paper marked for identification "Transferree's exhibit No. 3" and tell what that is.

A. This, on the face of it, seems to be a copy of the regulations for the classification of oil shale lands.

Q. Read it and see if it is accurate.

A. I believe it is an accurate copy. These regulations, according to the note at the bottom, were adopted by the Oil Board at a meeting attended by the Chief Geologist and others April 5, 1916.

Q. From your own knowledge, having attended that meeting, and having been in touch with this situation as you have been, you will say positively that that is an exact copy of the regulations adopted?

A. I do.

Q. You prepared and edited the bulletin of the United States Geological Survey known as Bulletin 641-F., did you not?

A. I did.

Q. Has the information which you have obtained since that time of making this report with reference to the shales in the Colorado area caused you to change your opinion with reference to this classification of the various elements of the Green River series?

A. In general, the statements as given in that bulletin to the effect that the most important beds of oil shale occur in the middle member of the formation, are correct and stand that way today. But we have had some opportunity to study the other members and do find that *there are beds of oil shale in both the upper and the lower members, which in some places are quite rich.*

Q. Then at this time you are of the opinion that *the valuable strata of oil shale are not confined entirely to this middle section of the Green River series?*

A. I am of that opinion.

Q. And you have found in your experiences strata in the other portions of the Green River series which you consider the basis for a classification of the land as chiefly valuable for oil shale?

A. There are in both the upper member and the lower member beds which will qualify according to the table submitted as exhibits 3 and 4, according to those regulations, and I believe they are valuable deposits.

Q. Aside from the tables adopted by the Government for classification and as a practical proposition, what elements enter into the question of the comparative value of strata of shale from a commercial viewpoint?

A. I can name many, probably not all of them. Among those that I think of at this time are the thickness and richness of the shale bed which it is proposed to operate; its attitude geologically, that is, whether it is horizontally bedded or a steep dip; its attitude topographically, whether it is three thousand feet above the lands upon which it will be necessary to treat it, or whether it is at a much lower altitude and near said retorts; the character of the shale, its action in a retort; in other words, its chemistry; the products which may be derived, primary products and secondary products which may be derived by its treatment; the distance it is from transportation; the availability of lands to its outcrop for the installation of plants, of residences, etc., for workmen; the physical character of the shale as it has a bearing upon the methods of mining necessary; the methods of getting it out of the ground; the physical character of the shale and its effect upon the crushing of said shale; the presence or absence of an adequate supply of water for the operation of plants, the distance to which pipe line must be run to get said water. Probably many other factors.

* * * * * * * * * *

Q. From your experience, would you say that it was wise to always operate the richest strata of shale alone in the retorts?

A. No. I have made many distillations in a small pot retort. Upon that I base the statement that there are certain beds of rich shale, which shale when heated will slag, fuse, so that it is difficult to remove from a retort, that is, a retort of that type. I can conceive of a condition whereby such a shale might be profitably operated in the same retort by its mixture with a leaner shale of a different type, a mixing of ore, in other words, to make a profitable treatment.

Q. What do you obtain in the way of products, other than oil, from the treatment of Colorado oil shales?

A. So far as I know from actual experience, and from the testimony of others who have worked on the oil shale of northwestern Colorado, the Green River formation, the primary products of distillation are an oil similar, not the same but similar, to petroleum; nitrogen, which comes from the shale in the form of ammonia and which can be certainly converted into ammonium sulphate, if so desired, and a combustible gas. So far as I know from actual experience, *there is no use for the residue which constitutes something like 60 per cent at least, by weight, of the original raw rich shale.* The residue will be, of course, increased in percentage as the shale decreases in its richness.

Q. Upon what, in your opinion, does the question of the time when the shale will be operated in Colorado on a commercial basis depend?

A. There are *several factors*. In the first place, the chemistry, the mechanics of shale treatment, and all the stages of development of that phase of the industry, are at such a position at the present time that we could not today produce shale oil profitably and in quantity. Research is necessary. That takes time. After we have the completion of that research, another period of time is necessary for the installation of machinery, the whole depending upon the values to be derived from the shale as compared with the costs of producing those values. The values are defined by the values of competing products. The principal product, primarily, will be crude shale oil. The question of the values of the crude shale oil in dollars and cents is a question of the values of its competitor, crude petroleum; and *that depends on the stage of the petroleum industry*, as to the production relative to consumption.

* * * * * * * * * *

Q. *Is there any doubt in your mind, Mr. Winchester, that at the time there comes a demand for the shale oil, that the oil will be produced and that method of its production will be successfully devised?*

A. *Absolutely no doubt at all.*

Q. And it is then your opinion that this demand will come *when the production of petroleum has fallen below the consumption and imports?*

A. *Yes, if not sooner.*

Q. And that time may come within a very short time, or it may be farther away?

A. It is the estimate of these persons making this report just referred to, *that it will come soon*, and I believe they have the right information.

Q. What is the situation there with reference to the uniformity of these strata through the Green River series in this part of Colorado?

A. From my more or less recognizance type of examination over all the shale fields of northwestern Colorado, I believe that I am perfectly safe in saying *the beds of oil shale in the Green River formation are remarkably persistent;* that over distances of six, ten, perhaps greater distances of miles, we will find a comparatively uniform thickness and comparatively a common richness of a single bed. That is the result of the examination primarily of the beds in the middle or richer section of the formation, but from evidence collected by myself, I believe positively that these beds in the lower part of the Green River formation are of similar character, and I know that at several localities beds of shale in that general zone, I cannot say that they are the same, but in that general zone there are beds which run from sixteen to twenty gallons per ton and have thicknesses of more than one to two feet.

Q. This policy of classification of lands according to certain data is one not for today but for a great many years, isn't it, more or less of a conservation policy?

A. Yes, but that policy is defined or the definitions of shale land arrived at after a study of practices in the only places that shale is under commercial development, what they are doing today, and the limits are placed such that they are not far different from foreign commercial practices of today in some countries. In other words, *the limit of two feet of shale, fifteen gallons to the ton*, as placed by these regulations,

it would be necessary to classify a fifteen-gallon shale as valuable, which isn't much different from what they are doing in Scotland on a commercial basis today; in other words *they are not the radical conservation type of regulations.*

Q. Mr. Winchester, I want to ask you this further question as an expert on oil shales. In view of what you know of the industry and the present conditions of the petroleum industry and the reserves which are estimated still to exist in the petroleum structures, I will ask you whether or not, as a present existing business proposition, you would advise the purchase of oil shale lands in this area in question and the performance of research work and experimentation with a view to being ready when the demand came?

A. *I have advised several parties to that effect, and where I did advise them they got shale lands and performed research work. If I had any money of my own for investment, I think I should get into it.*

Q. You have done that then as an initial step to be taken at this time from a business standpoint?

A. *It is none too soon to start right now; it must be done, we must have oil.*

SUMMARY

1. The case under consideration, from which verbatim extracts have been taken, is the first case on record wherein definite facts have been given under oath and opinions by experts offered in open court.

2. The weakness of the government's case is due not to a lack of ability on the part of the government witnesses, but to a lack of facilities to secure worthwhile information. The governmental method seems to be at fault.

3. The minimum requirements for commercial oil shale land is 15 gallons to the ton in a bed not less than one foot in thickness.

4. A thorough examination of the land and extensive experimental work is necessary as a preliminary to commercial oil shale operations.

5. The economic features, aside from richness of the shale itself, are of paramount importance.

6. The oil shale deposits in Colorado are 50 per cent richer than the Scottish deposits.

7. When the oil curve of consumption crosses the oil curve of production oil from shale will be produced on a commercial basis regardless of the price of oil at that time. This time is in the very near future.

8. Formerly it was thought that only the middle section of the Green River formation contained valuable oil shale. Now it is known that all three sections are valuable for a vertical distance of 2370 feet.

9. Thoroughness of work is well illustrated by the testimony of one witness that he had made 6,000 tests on oil shale.

10. The oil shale industry is a large, low grade project and requires much capital, time, and experimentation.

ESTHONIAN PRIZES FOR OIL SHALE FURNACES

VICTOR C. ALDERSON

In Esthonia, one of the new Baltic states of old Russia, oil shale forms the chief source of national wealth. The shale is so rich in combustible material that it can be used raw as a fuel, both for commercial and domestic purposes. The Esthonian government has appropriated large sums to develop the industry, has invited foreign capital, and has granted valuable concessions. In order to increase the use of oil shale as a fuel and to use it efficiently, the Ministry of Trade and Industry of Esthonia offered twelve prizes, in amount from 9,000 to 100,000 marks each, for the best designs submitted of the following types of furnaces, for the combustion of Esthonian oil shale:

1. Railway locomotives
2. Stationary steamboilers
3. Central heating plants
4. Forges and various metallurgical furnaces
5. Lime burning
6. Stoves and fireplaces in dwelling houses

The government gave the following composition of Esthonian oil shale:

	Moisture % %	Sulphur %	Volatiles Exclusive Steam	Coke %	Ash %	Heating power in Calories	Specific wt.
Type 1	15—25	1.5	2/3 of the organic components	1/3 of the organic components	25—35	2600—4000	1.3
" 2	20—30	to			25—35	2800—3600	to
" 3	25—35	2.2			30—40 Including 5-10% CO_2 which is formed through combustion of $CaCO_3$	2020—2800	1.5

Chemical Composition of Oil Shale.

According to Research by	C %	H %	N %	O %	S %
Schamarin	70.5	7.2	0.2	22.0	—
Kogermann	71.58	7.4	0.48	19.04	1.5
Fokin	72.37—73.4	8.31—9.02	0.68	16.72	1.6—2.6
Sarembo	70.0	7.9 —8.4	1.40	18.20	1.4—3.9

The Ministry also offered to supply oil shale at half the market price to competitors requiring oil shale for tests.

The prizes were arranged as follows:

No. of Type	First prize	Second prize
1	100,000 Marks	50,000 Marks
2	72,000 "	36,000 "
3	36,000 "	18,000 "
4	36,000 "	18,000 "
5	48,000 "	24,000 "
6	18,000 "	9,000 "

The competitors were required to send to the Ministry not later than March 15, 1922, detailed drawings (scale not under 1/20) with specifications. The drawings and specifications were required to be perfectly clear so as to facilitate the construction of the furnaces. The competitors were also required to inform the Ministry where tests could be carried out should such a furnace as they submitted already exist. The drawings and specifications had to be submitted in a sealed envelope, marked with a pseudonym, and the name and address of the competitor submitted in a separate similarly marked envelope. Furnaces already described in the Esthonian or Foreign Press, or which had already been awarded a prize elsewhere, were not allowed to compete. Competitors were at liberty to increase the heating power of the shale by preliminary drying or breaking, or by converting it into generator gas. Drawings and specifications of apparatus necessary for preliminary or subsequent processes, as well as the cost and estimate of working expenditure of the complete furnace, had to be submitted.

The following were appointed as judges:

1. Professor Witlich
2. A representative of the Esthonian Technical Society
3. A representative of the Association of Esthonian Industrials
4. A representative of the Ministry of Trade and Industry
5. A representative of the Railway Administration
6. A representative of the State Oil Shale Industry
7. A representative of the Association of Esthonian Engineers

The awarding of a prize would not, in any way, affect the rights of the inventor nor would it prevent his registering the invention as a patent. The judging committee was allowed to recommend to the Government for purchase those designs submitted which were not awarded a prize. This action of the Esthonian Government is important because the use of raw oil shale as a fuel is objectionable because of the large amount of resulting ash. If a new form of grate can be designed by which this objectionable feature can be eliminated a new and important fuel is added to the world's supply.

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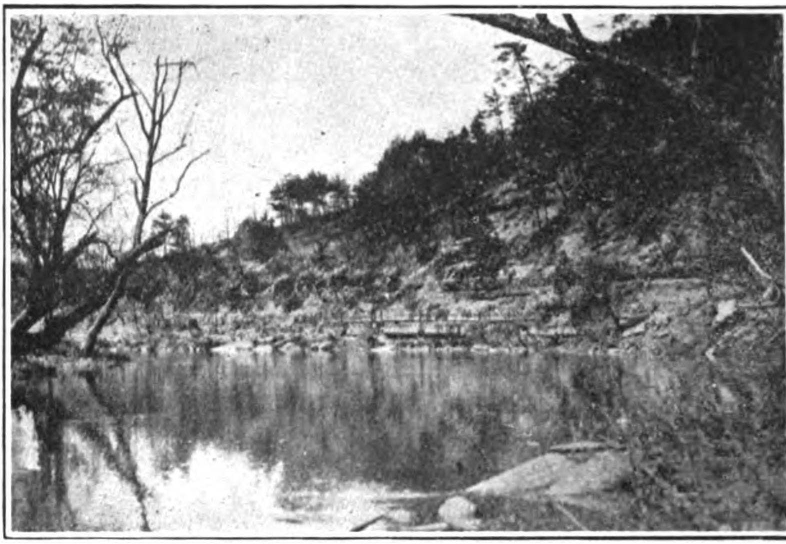
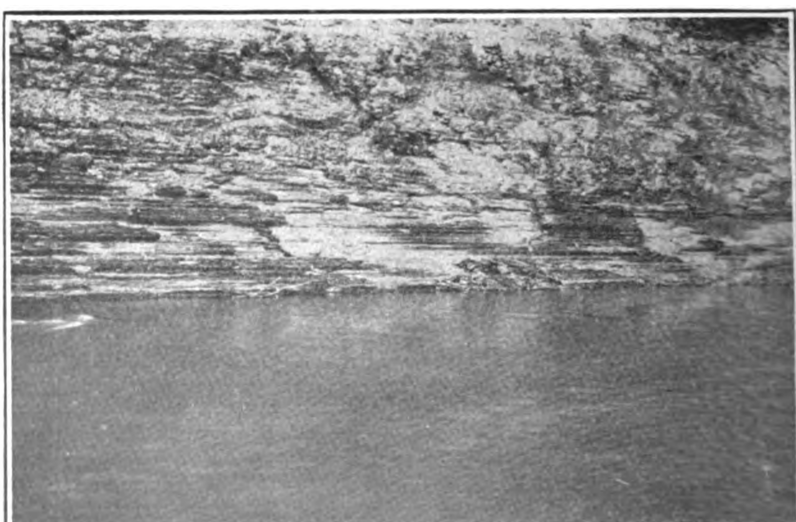


Red River and shale cliff. River is 110 feet wide and 12 feet deep. The ledge of rock showing just above the water line, is limestone and called the Irvine Oil Sand. It is the lower edge of the shale formation and makes a level stone floor under the entire deposit.



Shale cliff abutting Red River. This shows about forty feet of the 160 foot cliff.

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The Oil Shale of Kentucky

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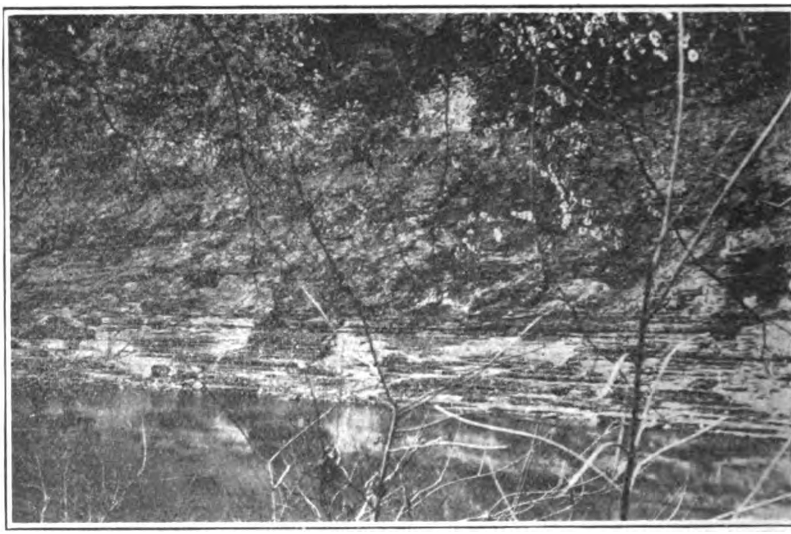
INTRODUCTION The most important development to be seen on the industrial horizon is the use of oil shale as a source of supply for crude oil, gasoline, lubricating oil, and ammonium sulphate. Wood long since ceased to be an economic basis for fuel; coal is now in its ascendency, but its use as raw fuel is uneconomical, wasteful, dirty, costly, and unsuited to the demands of the twentieth century. The time is not far distant when the use of raw coal, as fuel, will also be abandoned. Coal will be subjected to low temperature distillation and the products—gas, oil, and coke—will be used instead. This will conserve our natural store of fuel, save labor, remove the smoke nuisance, conserve our natural resources, and meet the demands of our advancing civilization. With this economic shift from raw coal to its distillation products will come the use of oil shale, after it has yielded, by a process of destructive distillation, gasoline, lubricating oil, gas, and ammonium sulphate. To one who will take a broad, comprehensive view of our economic and industrial future, it must be evident that radical changes are soon due in well nigh every phase of our coal, oil, gasoline, gas, and fuel conditions, both as to production and use.

GEOLOGY In a far distant geological age southern Ohio, Indiana, Illinois, and Kentucky were the bed of a vast ocean, now called the Devonian sea. In the bottom of this sea was laid down, by the erosion of the adjacent land, a vast amount of clay or shale, now known as the black shale. To this deposit fish and other forms of sea life contributed their remains in large quantities. At this stage of the earth's history land life was inconsiderable, but sea life was abundant. Consequently this particular deposit has a character all its own, as a result of containing an excess of the remains of sea life over land life. In succeeding ages layers of sandstone, limestone, and other sedimentary deposits were also laid down. Finally, there came, through the general contraction of the earth's cooling surface—like the wrinkles that come on a baked apple when it is allowed to cool—a gradual elevation of these horizontal deposits into the Cincinnati uplift, that is to the form of a flattened A.

In succeeding ages the apex of this uplift was eroded and only the sides were left sticking out. This erosion has gone so deep as to remove every stratum, in the middle of the anticlinal, down through the deposit first mentioned—that is the Devonian—and has left the Devonian jutting out all around the outer border of the anticlinal. These geological forces have enabled Kentucky to become the great state that it now is. Profes

sor Nathaniel Southgate Shaler, a native of Kentucky, was ever fond of calling the attention of his students of geology at Harvard to the effect of geological forces upon civilization. He never failed to recite that the peculiar character of the Devonian shale, the Cincinnati uplift, and the subsequent erosion, made possible the blue grass region of Kentucky. I well remember that in his lectures, thirty five years ago, he called attention to the oil bearing qualities of these Devonian shales, which form a fringe about the blue grass region, and his prediction that they would some day become of economic value and a source of great wealth to his native state.



Shale cliff on Red River near Clay City, Ky. 145 feet high.

LOCATION OF THE OIL SHALE

The blue grass region of Kentucky covers an irregular horseshoe area of fifty miles in radius with Lexington as its center. The geological forces described and the exceptional composition of the Devonian shale have made this region world famous. The blue grass section is surrounded by bluffs and escarpments of Devonian shale, and other sedimentary rocks, to a total length of 250 miles. This fringe is cut into by ravines and gullies till the entire frontage is irregular to the last degree. These bluffs form the oil shale deposits. This fringe of outcrops extends from Vanceburg, on the northeast, in a generally southwesterly direction, then westerly, then northerly to the vicinity of Louisville. From Louisville the shale extends into Indiana and from Vanceburg into Ohio. Thus the blue grass region of Kentucky is in the bottom of a great bowl, the bottom of a great anticlinal with its apex eroded, fringed by bluffs of oil shale, of Devonian age. Another outcrop of this Devonian shale occurs along the Cumberland river in the southern part of the state, but it is small compared with the main body which surrounds the blue grass region. Besides this deposit two others are recognized geologically: the cannel shales in both the eastern and western coal fields and the Sunbury shales, neither of which is now regarded as commercially valuable. Oil shale outcrops in thirty-three counties of the state.

EXTENT OF THE DEPOSITS

In places the outcrop of shale reaches a height of 200 feet but a conservative average for the 250 miles of exposure is fifty feet. The dip is slight so that the deposit is easily worked for an average of three miles back from the outcrop. The average of twenty samples gave 130 pounds as the weight of a cubic foot of shale. Prof. C. S. Crouse, of the University of Kentucky, who has travelled over the entire district and has made a careful, conservative survey, estimates that there are 1,000 square miles of this shale exposed and available for commercial exploitation by open cut and steam shovel methods. On the basis of an area of

Red River and the shale hill immediately adjacent. The hill measures 164 feet high

1,000 square miles, 50 foot thickness, and 130 pounds to the cubic foot, there are available, therefore, 90,604,800,000 tons of shale. This is a stupendous figure, but the oil shale deposit itself is stupendous. Not only is this great deposit easily accessible, but the greater part of Kentucky, except the blue grass region, is underlaid by an extension of this deposit. All of which forms a deposit beyond accurate computation. It may be difficult for the average human mind to appreciate the meaning of these figures, but in time we shall become accustomed to thinking in lots of a billion barrels of oil as we have become accustomed to a billion dollar Congress.

CONTENT OF THE DEPOSITS

Dr. Willard R. Jillson, State Geologist of Kentucky, has given much attention to these oil shales. Prof. C. S. Crouse, of the University of Kentucky, has tested 20 samples from various sections of the state. He found the largest yield of oil from the shales of Taylor County, 27.75 gallons to the ton: the lowest from Rockcastle County, 8 gallons. He gives the average oil content from these twenty samples at 16.08 gallons with a possible 25 or 30 gallons a ton from over a large area of well chosen ground: the average specific gravity at 2.173: the average weight of a cubic foot 129.37 pounds: sulphur from 1.50 to 4.15 per cent: The sulphur occurs as pyrite and is so unevenly distributed that it is impos-

sible to get an accurate sulphur content on anything except the particular sample under examination. The total amount of sulphur in the shale. however, will probably cause no difficulty. Nitrogen from 0.26 to 0.57 per cent: moisture from 0.83 to 1.59 per cent: volatile combustible matter from 16.72 to 10.26 per cent: fixed carbon from 4.61 to 10.06 per cent: ash from 73.43 to 83.90 per cent. A sample of the Clay City shale, tested at the Colorado School of Mines gave 17 gallons of oil and 0.52 per cent of nitrogen. When a large number of samples are taken in the field it is virtually impossible, in all cases, to get fair unweathered samples that represent the shale as it will be when mined. After due

A shale outcrop on the property a mile away from the foundation site. Loose shale in the foreground is the result of a blast which was placed higher up.

consideration is given to all the factors involved, it seems fairly conservative to estimate that one half a barrel of oil (21 gallons) to the ton of shale can be recovered on the average from the Kentucky oil shales.

EXPERIMENTAL WORK AT THE UNIVERSITY OF KENTUCKY

At the University of Kentucky, Professor C. S. Crouse and E. E. Hedges of New York, have been developing a retort especially adapted to treat the Kentucky shales. This retort is cylindrical in form, slightly inclined (¾ in. in 15 feet), 15 feet long, 12 inches in diameter, heated by 12 external burners, adjustable to any angle, and without any internal device to advance the shale. The shale is advanced merely by the inclination and revolution of the retort. The shale, broken by breakers and rolls to pea size, is fed in at the upper end and passes to the lower end where it drops out as spent shale. Superheated steam is injected at the lower end so that a counter current is formed by means of which the generated gas and oil vapor is driven out at the upper or feed end. The throughput is three tons in 24 hours, but the larger commercial retort, operating on the same principles, is expected to have a minimum throughput of 25 tons in 24 hours. The heat is graduated from 400-500 degrees F. at the feed end to 920 degrees F at the discharge end. Since

the vapors are withdrawn at the feed end and this is always the cooler end, the vapors are never subjected to a higher temperature than that at which they are formed. The time in transit of a particle of shale is 45 minutes. The spent shale will be treated with superheated steam to recover the fixed carbon as gas and also to remove the remaining nitrogen as ammonia gas. Further work with this retort is now in progress.

THE DEVON OIL SHALE PRODUCTS COMPANY

The Devon Oil Shale Products Company, capitalized at $1,250,000, is in the vanguard in the development of the oil shale deposits of Kentucky. The company has acquired a 424 acre tract near Clay City, Powell County. The average vertical height of the exposure is 80 feet, but in places it is much higher. The excavation into the hill near the plant site shows a vertical height of 130 feet of continuous shale. The overburden is negligible. At the foot of the hill is Red River, 110 feet wide and 12 feet deep at low water. There is also ample dumping ground. The company states that it can contract for the mining and delivery of the shale to the breakers for 25 cents a ton. Thus the economic factors—cheap mining, large water supply, and dumping ground—are all favorable. The company is erecting a plant of 1500 tons daily production from which is expected 750 barrels of shale oil and 37½ tons of ammonium sulphate. The laboratory experiments on the Devon shale of Estill County by Professor Crouse gave 20.7 gallons of crude oil to the ton from which was obtained 5.11 gallons of gasoline and naphtha, 10.48 gallons of kerosene and light lubricating oil, and 5.00 gallons of residue. These results were obtained from a small retort without the use of steam. Later experiments with steam have materially increased the yield of crude oil.

One sample of shale submitted by S. E. Barnwell of the Devon Oil Shale Company to the Pittsburgh Testing Laboratory, gave the following results:

Analysis of Shale—

Silica	36.32%
Alumina	11.60
Iron oxide	2.00
Titanium oxide	.40
Calcium oxide	5.72
Magnesium oxide	3.82
Sulphur	2.01
Potash	2.91
Soda	1.30
Total nitrogen expressed as ammonia	1.21
Loss on ignition (organic matter, etc.)	32.71

Distillation Test—

Maximum temp. of distillation	1560 deg. F.
Oil recovered per ton of shale calculated from small scale distillation test	160 lb. or 20.1 gal.
Gas produced per ton of shale calculated from small scale distillation test at 30″ mercury pressure and 60 deg. F.	3600 cu. ft.
Yield of ammonium sulphate per ton of shale calculated from small scale distillation test	4.32 lb.
Carbon in residue	13.02%

*Temperature too low to recover ammonia-nitrogen percentage indicates 97.8 pounds at 100% recovery.

Examination of Oil—

Specific gravity at 60°F.	0.957
Sulphur	1.56%

Distillation—

1st. Drop over at	158°F.
10% " " "	368°F.

20% " " "	429°F.
30% " " "	500°F.
40% " " "	550°F.
50% " " "	597°F.
60% " " "	617°F.
83% " " "	727°F.

(partial vacuum)

Residue mainly coke.

Another sample submitted to the Detroit Testing Laboratory gave the following:

Products of Eduction—

Oil-gal. per ton	Gas-cu. ft. per ton	Ammonia as am. sulfate	Potash as K_2O lb. per ton of spent shale
22.7	4167	97.8	58.8

Fractional Distillation of Oil—

Initial boiling point of oil	150°F.
Gasolene fraction	32%
Kerosene fraction	23%
Lubrication oil fraction	31%
Tar residue	14%

Details of Distillation—

	Initial distillation point	150°F.
	(1% Distills over at	200°F.
	(2% " " "	300°F.
	(3% " " "	320°F.
	(8% " " "	340°F.
	(13% " " "	360°F.
Kerosene	(17% " " "	380°F.
23%	(19% " " "	400°F.
	(23% " " "	420°F.
	(25% " " "	440°F.
	(32% " " "	450°F.
	(33% " " "	480°F
	(34% " " "	500°F.
	(35% " " "	520°F.
	(37% " " "	540°F.
	(40% " " "	560°F.
	(43% " " "	580°F.
Lubricating	(55% " " "	600°F.
oil 31%	(56% " " "	620°F.
	(58% " " "	640°F.
	(61% " " "	660°F.
	(65% " " "	680°F.
	(78% " " "	690°F.
	(86% " " "	700°F.
	Tar residue— 14%	

Analysis of Gas—

Average sample	Collected below 800°F.	Collected 800°-1000°	Collected 1000°-1200°
Carbon dioxide	13.8%	19.4%	24.0%
Illuminants	3.5	2.4	1.2
Oxygen	.5	.3	2.3
Carbon monoxide	2.4	5.4	9.9
Hydrogen	12.3	20.2	27.7
Methane, ethane, etc.	64.5	51.7	26.8
Nitrogen	3.0	.6	8.1
B. t. u. per cu. ft.	748	650	410
Av. B. t. u.	603		
B. t. u. value of gas per ton shale			2, 512,702

Analysis of Shale as Received—

Loss on ignition—organic and vol.	35.36%
Ash	64.64%

Nitrogen as NH_3 .... 1.26%
B. t. u. .... 4212.
Potash on treated shale 1.90%; on raw shale 2.94%

Potash recovery depends upon condition of spent shale and as the potash is not water soluble its recovery is not a practicable commercial operation.

Details of Eduction—

Initial oil over at	280°F.
All oil over at	1200°F.
Final temperature of retort	1200°F.
Oil recovered	22.7 gal. per ton
Gas recovered	4167 cu. ft. per ton
Heat values of gas	630 B. t. u. cu. ft.
Gravity of oil	21° Beaume
Specific gravity of oil at 60°F.	.9272
Ammonium sulfate recovered at 1200°F.	2.44 lb. per ton
Potash as K_2O on treated shale	58.8 lb.
Potash as K_2O on treated shale	38.0 lb.

Conclusions:—

Detailed tests as listed above show—

1. This particular grade of shale will yield approximately 23 gallons of oil per ton.
2. The yield of gas is high in B. t. u. value and ample in quantity to supply the necessary heat for eduction and refining purposes. Careful calculations show that one ton of shale requires 1,000,000 B. t. u. to completely educe the oil contents when operating under well regulated conditions.
3. The shale shows nitrogen equivalent to 97.8 lb. ammonium sulfate per ton. A safe recovery figure is 50 per cent of total, making a recoverable amount of 49.8 lb. ammonium sulfate.
4. Potash—the amount of potash as K_2O present in spent shale appears high and should be discounted on large scale operations.
5. The grade of shale represented by the sample on which our tests were made would make it attractive as a commercial enterprise for the recovery of oil, gas, and ammonium sulfate.

Jenkins W. Jones, consulting engineer of Cincinnati, reported on this property and submitted the following analysis, made by F. C. Broeman & co., industrial chemists of Cincinnati:

RESULTS OF DISTILLATION OF RAW SHALE

Volatile matter or gas	910 cu. ft.
Ammonium sulfate	62 lb.
Oil	21.4 gal.
Potassium oxide (K_2O)	39.4 lb.
Specific gravity of shale	2.01

DISTILLATION OF THE OIL

Gasoline	12.50%
Coal oil	24.00%
Light lubrication oil	31.50%
Heavy lubricating oil	24.20%
Asphaltic residuum	7.80%
Refining and other losses	0.00%
Totals	100.00%
Gravity of the oil	21.4—Be

ANALYSIS OF THE RAW SHALE

	Per cent
Volatile matter	3.49
Fixed carbon	7.10
Ash	78.60

Water	2.50
Oil	8.00
Ammonia	.31
Total	100.00%

ANALYSIS OF THE SPENT SHALE

	Per cent.
Silica (SiO_2)	55.12
Iron oxide (Fe_2O_3)	1.92
Aluminum oxide (Al_2O_3)	19.12
Calcium oxide (Ca O)	17.71
Calcium sulfate (Ca S O_4)	1.27
Magnesia oxide (MgO)	2.87
Potassium oxide (K_2O)	1.97
Undetermined	.02
Totals	100.00%

He gave a section as follows:

1.	Berea grit as base of Carboniferous series	2 feet
2.	Plastic fire-clay	4 "
3.	Sunbury black shale (Vanceburg)	8 "
4.	Clay and black shale mixed	10 "
5.	Uniform bed of black Devonian shale	105 "
6.	Section of alternating gray and black shale	7 "
7.	Black shale	6 "
8.	Hard sandstone cap	4 "
9.	Gray shale and clay bands overlying Corniferous	8 "

THE SCOTT PROCESS

The Kentucky oil shale resembles closely the Scotch shale in that it produces less oil and more ammonium sulphate than other American deposits. For this reason, a modified Scotch retort would seem to be well adapted for use on this deposit. The Devon Oil Shale Products Company has, consequently, accepted the Scott retort designed and developed by John D. Scott at the Detroit Testing Laboratories. The purpose of this design is to retain the best features of the Scotch retort, but to make such changes as would increase its efficiency. This has been done in three ways: first, by making the base of the retort considerably larger than the top, so as to decrease the time in transit of the shale down the retort and to avoid caking: secondly, by installing a preheater to drive the moisture out of the shale and to raise the shale nearly to the temperature of distillation before it enters the retort proper: thirdly, by a more efficient application of the heat around the retort.

A single retort of the Scott type is 20 feet high, set on a solid foundation of concrete and steel, and consists of ten fire clay sections. These sections are stacked one above the other and form a single chamber, similar to the Scotch retort, but tapering more so as to enable the shale to descend more rapidly and thus increase the daily throughput. Above the retort is the steel magazine into which shale from the bunkers is fed and from which shale is fed into the top of the retort, as spent shale is drawn off at the bottom. Above the magazine are the steel bunkers which contain the preheating device.

The progress of the shale from its raw stage to the commercial forms desired is substantially as follows: After being broken down from the cliff the shale is transported to the gyratory breakers and reduced to the size of walnuts. It then passes to the bunkers and is preheated to drive off the contained water, and to raise the temperature nearly to the distillation point; then it goes to the magazine to be fed to the top of the retort as needed. In passing down through the retort the shale is subjected to a gradual increase of heat from 400°F to 2000°F at the eighth fire clay section where the superheated steam is injected.

No heat is applied to the two lowest fire clay sections, so that the spent shale cools slightly and is more easily removed by the evacuating screw. From this brief description it will be seen that the fundamental principles of the Scotch retort, which have proved practically successful after many years of commercial use, are retained and at the same time the retort is so modified as to improve its efficiency and increase the daily throughput. The daily capacity of the Scotch retort averages only four tons of shale. According to Engineer S. E. Barnwell, of the Devon Company, the capacity of the Scott retort is 20 tons of shale. This passes through in from six to seven hours, so that the daily through-

Oil shale Knob. This is typical of the Ky. Shale country tho these Knobs are often connected by ridges. This hill is all shale with only a foot or so of weathered shale to support vegetation Photo by C. S. Crouse. Sept. 1920.

Typical Unweathered Ky. Shale as exposed by blasting away weathered Material. The Total vertical Shale in this hill is about 150 ft. The exposure shows near the bottom.—Photo by C. S. Crouse. Sept. 1920.

put is about 70 tons, to be compared with four tons in the Scotch retort. Also the non-condensible gases, together with the water gas formed, will yield 4167 cubic feet to the ton of shale, of an average calorific value of 603 B. t. u. This gives 2,500,000 B. t. u. to each ton of shale. On account of the high thermal efficiency of the retort only 900,000 B. t. u. are needed for each ton of shale. Thus, according to Engineer Barnwell, each retort, when once in operation, will supply non-condensible gas in amount more than sufficient for plant purposes.

In the Scott retort, as in the Scotch, the shale in its descent is subjected to a gradual increase of heat; gas and oil vapors are generated, which, by the sweeping force of the steam injected at the bottom, are carried out quickly. The steam also gives an even dissemination of the heat, forms a water gas by combination with the carbon in the red hot shale, and supplies the hydrogen to combine with the nitrogen in the shale to form ammonia. The resulting gas and oil vapors with the ammoniacal liquor are all drawn off together, as in the Scotch retort, to tanks and condensers. The ammoniacal liquor goes to the sulphuric acid plant to yield ammonium sulphate, the oil is refined for the market, and the non-condensible gases are used for fuel.

MT. STERLING

The possibilities of developing the Kentucky oil shales have already attracted the attention of investors, and development companies have been formed. Among these is the Central Oil Shale Corporation of Pittsburgh, which has acquired an excellent tract of 800 acres of land eight miles east

of Mount Sterling, in Montgomery County. The property consists mainly of two converging systems of low hills which are virtually solid shale, averaging 75 feet in height, with virtually no overburden. Beneath the shale is a bed of limestone which outcrops in the valley and forms a foundation for retort and refining plants. An ample supply of water can be obtained from Slate Creek, a half a mile away: the railroad is also only a half a mile distant. This property has a happy combination of favorable economic factors: i. e., a large body of easily mined solid shale; no overburden; a nearby ample supply of water; proximity to the railroad; and a natural plant site. These special advantages, added

A small cut through a shale hill on the road between Clay City and Winchester.

to those common to Kentucky as a whole, make this property desirable for early development on a commercial scale.

SOURCES OF OIL Oil from the ground may be obtained from four different sources.

1. The high cost of raw coal in England, as a result of deep and expensive mining, has called attention to the uneconomical use of raw coal as a fuel. As a result, much experimental work has been done there on the low temperature carbonization of coal and many forms of retorts have been devised for the purpose. Ordinary coal, by low temperature carbonization, yields oil, gas, and coke, with sufficient volatile matter to make it desirable as a fuel, all of which together have a commercial value of fully three times that of the raw coal. The transformation of raw coal into these products is, therefore, an economic advance which, in the case of Great Britain, will be of great industrial value, and a distinct source of strength in economic competition.

2. Oil is also found in sands in a congealed state; that is, it does not flow and cannot be pumped. Such deposits are known as oil sands. The oil from these sands can be readily recovered by retorting and subsequent condensation, or by solvents.

3. Oil shale does not contain any commercially valuable oil as such, but it does contain, in the form of animal and vegetable remains, the chemical constituents which, when subjected to destructive distilla-

tion, yield oil and gas. The oil shale deposits of the world are so extensive that they form an original source of oil that will supply the world for centuries.

4. Oil is best known as a product of wells, either in a natural flow or as obtained by pumping. This is our present great supply. However, it is a waning asset and a supply of oil from some other source will soon become imperative. The most authoritative estimate of the amount of our oil reserves is that of the joint committee of the American Association of Petroleum Geologists and the United States Geological Survey. This committee reported that, in their judgment, there remained in the

Typical Ky. Oil Shale as exposed by Stream Action in a Creek bottom——Photo by C. S. Crouse. Sept. 1920.

Typical exposure of shale in a road quarry near the top of a shale hill. This shows the usual negligible amount of overburden—Photo by C. S. Crouse. Sept. 1920.

ground January 1, 1922, nine billion barrels of oil recoverable by methods now in use. In the Kentucky oil shales alone there are, according to the conservative estimate of Professor Crouse, 90 billion tons of easily accessible oil shale. If this yields 17 gallons to the ton (the Colorado School of Mines test, an ultra-conservative figure) it could produce 36 billion barrels of oil or four times the amount that all the wells of the country will ever produce. In other words, Kentucky alone can produce, without undue expense or effort, a supply of oil four times as great as can be produced in the future from the combined wells of the entire United States. Furthermore, the oil to be obtained from the shale is a certainty: that from wells is at best only a guess.

WELL OIL VS. SHALE OIL

Some over enthusiastic persons who have seen a small laboratory retort in operation, with rock fed in at one end and oil dripping out at the other, have over worked their imagination and jumped to the conclusion that the production of shale oil would at once supplant the well oil industry. Nothing could be farther from the truth. Our present domestic supply of crude oil does not equal our consumption. Imports from Mexico are needed. Salt water has entered the Mexican pools. The peak production of many of our domestic pools—Mexia for example—has been reached. On the whole, our supply of oil from wells is uncertain. The gist of the matter is that when the total supply of oil, both domestic and Mexican, is less than the demand, a new source of supply will become imperative. The demand for oil will place the price at a figure that will enable oil to be produced from shale at a

profit. What that figure is in dollars and cents is immaterial. When that day comes the consumer will have to pay the price or industry will cease. There will be no sudden line of demarcation between use of well and shale oil. The change will come gradually. Rather than supplant the well oil, shale oil will merely supplement it. As the price of crude oil at the well advances, because of a lack of supply, it will approach the price at which shale oil can be produced. Then oil shale deposits, most favorably located for cheap commercial operations, will be developed and worked. Already some of the larger oil corporations, seeing the fatal day in the future, have purchased large acreages of oil shale land, have secured United States patent, have tested with the diamond drill or surface cuts, and know exactly what they have, as a reserve and potential oil supply. When the industrial demand exceeds the supply from wells they will be prepared to produce oil from shale.

It is unfortunate that too many well meaning but unbalanced organic chemists have given their attention to the many organic compounds that can be produced from shale oil, rather than to a fundamental study of the chemistry of the production of a good grade of shale oil. These chemists seem to forget that they are entering the field of the chemical manufacturing industry—already well established. At the present time an accurate scientific knowledge of just what goes on in the production of oil from shale is of far greater importance than the knowledge of how many interesting organic compounds can be produced.

A very simple, common sense, and business like point of view points to two important needs:

1. A retort of large daily capacity, foolproof in operation, scientifically constructed, that will produce a good quality of shale oil.

2. A topping or skimming plant that will produce gasoline with fuel oil remaining.

Thus the first oil shale plants would produce two standard products for which there is a large and increasing demand—gasoline and fuel oil. In the case of the Kentucky shales a third product would be added because of the presence of nitrogen in the shale and the use of water in distillation: that is, ammonium sulphate. It is the opinion of those best acquainted with oil shale problems and have the keenest vision into the future that the first oil shale operations will produce only gasoline, fuel oil, and ammonium sulphate. Other products must wait until these are well established upon a profitable commercial basis.

ADVANTAGES OF THE KENTUCKY OIL SHALE

1. The Kentucky oil shale more nearly resembles the Scotch shale than any other American deposit. For this reason, there is a substratum of knowledge and experience gained in Scotland that is immediately available to the American experimenter.

2. Although the oil derived from the Kentucky shale is less per ton than in some other American deposits, yet the presence of nitrogen allows the manufacture of ammonium sulphate and gives the entire deposit a commercial value in excess of what it would have for the oil alone. In Scotland the industry could not be made profitable without the ammonium sulphate, which some even regard as the main product, with oil only a by-product.

3. A convenient and ample water supply is neseccary for the production of ammonium sulphate on account of the use of steam. This water supply Kentucky has in abundance.

4. The location of the deposits in the center of a large population, with populous cities nearby, provides a home market for any of the products.

5. For the same reason labor will be easily obtained and the cost not excessive: ease of transportation, accessible railroad facilities, and favorable topography are also economic factors favorable to Kentucky.

6. The mining of the shale will be particularly cheap because of the small overburden and the exposure of solid shale in bluffs. For this reason, the shale can be virtually quarried rather than mined. The uniform character of the strata of shale will allow everything to go to the retorts without the need of any selective mining whatever.

7. The production of gas in the retorting process is sufficient to satisfy all fuel and power requirements.

8. The known and easily worked oil shale deposits of Kentucky will yield four times as much oil as is now estimated to remain underground in all the oil pools of the United States.

Oil Shale in Russia

VICTOR C. ALDERSON

The natural results of the war, added to domestic difficulties in Russia, have caused the country to give close attention to its domestic supply of fuel. The Russian Fuel Shale Bureau was organized to study, to develop, and to bring to a commercial basis bodies of oil shale known to exist within the country. The work of the Bureau has been hampered by a lack of trained technical men, poor railroad facilities, inefficient labor, depreciated currency, and a host of minor obstacles. Hence the results are not to be compared with the results obtained in countries where more normal conditions prevail. However, a brief survey of the shale potentialities of Russia may not be out of place.

Oil shale, in deposits of commercial value, are known to exist at five localities.

a. At Obschtij-Sayrt in the district of Busuluk.

b. At Pugatschew, government of Samara.

c. At Kortschew and Ostaschkow in the Volga district, government of Twer.

d. At Undori and Kaschpur in the Volga district, government of Ssimbirsk.

e. At Weimarn, on the Baltic railroad, near Petrograd.

The deposits at Ostaschkow are nearly horizontal with an overburden of less than three feet, so that it can be cheaply mined by steam shovels. It is dark grey in color, lies less than a mile from river transportation, and has a thickness of ten feet.

Official analyses gave:

Volatile matter	34.60 to 38.00 per cent
Ash	50.30 to 50.40 " "
Tar	8.00 to 11.00 " "

At Ostaschkow the Russian Fuel Shale Bureau has established its experimental plant, with laboratories and experimental retorts. These retorts are of cast iron, six in number, and contain two tons of shale each.

Near Weimarn the shale is mined from surface workings and is shipped to Petrograd and Kronstadt where it is used as raw fuel in the gas works and other industrial plants.

In the Volga district the main deposits that are now being worked are at Undori in the state owned deposits of the Stephen basin and near Kaschpur. In 1920 a thousand men were employed. The thickness of the workable shales averages twenty feet, the specific gravity from 1.30 to 1.40 and the estimated available amount 639 million metric tons.

Tests of the Kaschpur oil shale at the Ostaschkow experimental plant of the Russian Fuel Shale Bureau gave an average yield of tar of 10 per cent of the dry weight of the shale. It was noted that with the increase of temperature there was an increase of gas produced and a decrease of tar. Slow distillation gave a high yield of tar and a low yield of gas. Complete distillation gave, up to 150 degrees centigrade, 6.78 per cent of products. Ichthyol was also obtained.

We have yet to show more specific relationships between the probable origin of the shale and the composition of the kerogen, the various extracts and the carbonaceous matter in the residue. It would also be desirable to repeat this work on other Colorado shales of greater or lesser richness, and shales of different types from other regions. A number of refinements could be made in both our apparatus and technique. We hope to make further studies, in which such improvements will be made, and secure additional data, especially on the yields of volatile constituents during each heating process and the composition of the gases evolved.

SUMMARY:

1. The theories of the origin of oil shales were discussed in attempt to throw light on the nature of the kerogen.

2. The work of Engler, Lederer and Tausz, McKee and Lyder, and others, was reviewed critically.

3. A preliminary study has been made of the kerogen, or organic matter of a typical Colorado oil shale, of the mechanism of the thermal decomposition of this material, and of the liquid and solid products formed.

4. The kerogen was found to consist of two main types of organic matter: the oil forming and the coke forming constituents.

5. About eight per cent of the oil forming constituents were soluble in carbon disulfide. The remainder may be decomposed to a series of heavy bitumens from which the crude oil is obtained by destructive distillation. The coke forming constituents decomposed simultaneously to form fixed carbon and gas.

6. It was demonstrated that the primary decomposition does not occur at a definite temperature, as formerly supposed, but within a wide range of temperatures. In this work all the primary products were formed between 300 and 350° C. without producing any oil. The rate of de composition was much greater at the higher temperatures.

7. Conclusive evidence was submitted to show that the primary decomposition is not a depolymerization, as was previously assumed, but that the reaction resembled a very slow cracking.

8. The bitumens produced at the different temperatures were apparently not of the same composition.

9. The oil forming part of the kerogen was found to be a complex mixture.

10. It has been suggested that the methods used in this investigation might profitably be applied to a study of the tar forming constituents of coal.

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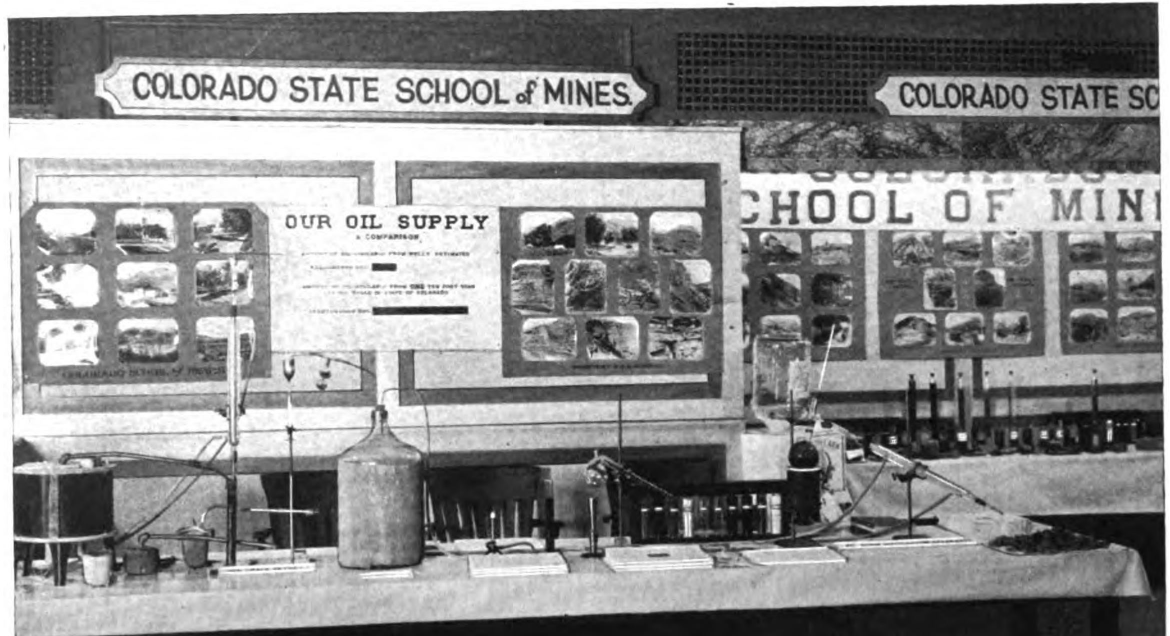

OIL SHALE EXHIBIT, AMERICAN MINING CONGRESS, CLEVELAND, O.
OCT. 9–14, 1922

QUARTERLY

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Vol. Seventeen | OCTOBER, 1922 | Number Four

American Mining Congress, Cleveland, Ohio

October 9-14, 1922

National Oil Shale Conference

TUESDAY AFTERNOON SESSION

October 10, 1922

The meeting of the National Oil Shale Conference of the American Mining Congress, held at Cleveland, Ohio, in the Cleveland Auditorium, convened at two o'clock, Dr. Victor C. Alderson, President Colorado School of Mines, presiding.

CHAIRMAN ALDERSON: Gentlemen: After asking you to come together for this conference, I think a few statements should be made, to cover, as it were, the entire field of the oil shale industry, and to call your attention to certain vital matters. Those of us who are interested in this work must realize that we are not dependent on past performances. Our work is of the present and future: we should realize that fully. The subject in which we are interested is not one that, in this country, has been standardized. It is not one that is on a regular commercial basis. We have little to say about what has been done, but much that may be done. This oil shale industry seems to me to be but a part of a very large industrial movement. I refer, of course, especially to the broad question of fuel.

To an onlooker, it seems that the use of raw coal as fuel is, in the first place, dirty; in the second place, it is uneconomical; and in the third place, it is entirely unnecessary. In England, the price of coal has gone so high, that there is a very strong, a wide-spread, movement to turn the raw coal, not only the high grade, but the low grade, by low temperature distillation, into gasoline, and oil, and a coke that will serve as ordinary fuel. Now, that is a large movement; it has made some progress in this country, but is a movement that, I think, will make still greater progress in the future. The use of raw coal as fuel, except in a few favorable localities, is near the end. Another source of fuel is, of course, gas; another source of power is from the hydro-electric plants, but in the future oil will be our chief raw fuel. The report of the combined committee from the U. S. Geological Survey and of the American Association of Petroleum Geologists, made a guess that we have left about nine billion barrels of oil in underground pools, that can be reclaimed by present day methods. As a matter of fact, in Colorado alone in one ten foot seam we know we have four times that amount and great quantities in other states. (Laughter.) In all probability we shall hear from some of those other states, especially Kentucky, because Kentuckians are sensitive on that point. The basis, it seems to me, for the economic development of this nation and of all

nations is a plentiful supply of oil. When the time comes that we must have oil from some other source than from wells, we shall find the oil shale deposits are our main source of supply. There is no alternative; we must have oil; the question of cost will be a distinctly secondary one.

This movement is so broad, as I look over it, that I cannot help calling your attention to the fact that the shales that are productive of oil are world wide in their extent. In Norway and Sweden, the government has laid aside a large sum of money for experimental work and development of their own oil shale deposits. In Esthonia, the new Baltic state of old Russia, the oil shale deposits form the main national wealth. They are being developed faster, I think, than in any other place in the world. In Germany, the deposits are being exploited by the government with the single idea of making Germany independent of oil importation. In New South Wales, their rich deposits are now being worked on a successful basis. They have had technical, labor, and many other troubles, but now, I think, those are overcome, and there will soon be produced a large supply of oil from the oil shale deposits alone for local use in New South Wales. In Tasmania, the government has made a substantial appropriation for the field examination of the oil shale deposits, and also for retorting, refining, and other experimental work. In Canada there are also great deposits, the Anglo-Persian oil company has put aside five million dollars to develop and experiment on the oil shale in Nova Scotia alone. Rich deposits are known also in Newfoundland and in New Brunswick. In our own country there are a number of states in which large deposits can be developed into successful commercial enterprises. When people talk about the oil shale industry supplanting well oil, I think it is wise to correct them. I do not believe that in our life time one will ever supplant the other. Shale oil will merely supplement well oil. In localities where oil shale can be worked to advantage plants will go up and the local community will be supplied with oil and its derivatives. Such plants will go up here and there, wherever they can be operated on a successful commercial basis. In looking over the field, I think it is wise to remind you that this whole business is one of several chapters, and one should not let himself regard it as being of one chapter only. We must remember that it involves the testing of the shales, the mining, the crushing, the retorting, the refining, and, finally, the distribution of the finished products. It is a long continuous series of operations. No one of them is of such tremendous importance that it overshadows everything else. Different men, with different ideas, will attack the problem at different places. Essentially, there is necessary a very large supply of the best grade of engineering ability; a supply of chemical ability and then, more than that, financial ability, because this is not a one man game. It is a project of very large tonnage, of large capital, and large scale operations. We should not fool ourselves by thinking that the work is like that of the prospector working out in the hills, who works on a gold placer and gets his pay every night when he makes a clean up.. It is not that at all. It is a project of large capacity, and of so scientific a character that the technical ability, in order to carry it through successfully, must be of the very highest order.

There are, in addition to the general features I have called your attention to, one or two of pressing importance at the present time. To those of us who are close to the western deposits, the question of what constitutes valid assessment work is of immediate concern. At the present time a man owning an oil shale claim and doing the assessment work, does what he thinks will pass, and then it is for the General Land Office to decide whether it will or not. Those of us who are close to the ground feel that the Government ought to decide what it will accept, so that a man need not waste his time and money and in the end find that his work will not be accepted. We feel that some careful thought should be given to the matter and a ruling made by the Department of

the Interior as to what will or will not be accepted as valid assessment work.

Another important phase to which I think we ought to pay attention is the propaganda that has been spread abroad covering the finding of large quantities of gold, silver, and platinum in our shales. Whether our shales contain the precious metals is, in some quarters, at least, a debatable point. Some men claim they have found them; others say they can not. We out west know that a good deal has been said on that subject. We seek light on the matter.

Another phase of this matter, which we should consider is one that bears directly upon the good character and reputation of everybody who pretends to know anything about this matter of oil shales; that is the activity of the fake promoter. Every new industry has had him; the oil industry had him; the mining industry had him; the timber industry has had him. It is unfortunate that, in the oil shale game, the crook has a splendid opportunity. The Government publishes exact figures; other publications of the best engineers contain the straight facts only. Those facts are so pronounced, the figures are so big, and the deposits so extensive that the fake promoter does not need to enlarge upon them. He can take Dean Winchester's government publications and get the basis for all the conclusions he needs. That is the first misfortune. The second misfortune is that he can take a piece of shale, a test tube, and a lamp and can make the oil and gas before the eyes of his dupes. Well, you put the governmental facts in his hands and give him a little piece of shale to work on, let him show the ignorant that he can actually make oil and gas; imagination and cupidity will do the rest. It is very, very easy for the fake promoter to sell his stock. I receive in my mail many letters from men who tell me that they dealt with a certain man in a certain city, they bought so many thousand shares of stock, that he has now left town, and his office is closed. The stockholder wants to know if I have any knowledge of the man or his company. Incidentally, he wants to know what his stock is worth. That happens again and again. I cannot help but impress upon you the fact that in this work the promoter has a very easy task. It is the simplest thing in the world, and the fake promoter intuitively recognizes it. In other fake promotions the promoter is obliged to lie, but that is not necessary in our work. Even those of us who give merely the facts are sometimes called liars. We are designated as members of the Ananias Club. Some people have been kind enough to refer to me as the president of the club. (Laughter.) But we are all in the same boat, if you please.

I have taken the liberty of outlining a few salient features for your consideration. We will go on with the work of the conference.

The main paper of the meeting will be presented by William C. Russell of Denver, Colorado.

(Applause).

(At this point a paper on "THE MINING OF THE OIL SHALES" was read by William C. Russell, consulting engineer of Denver, Colorado. See appendix).

MR. BARNWELL: (Ohio). Mr. Russell I should like to ask if you have any figures on the mining cost of shale; some of the figures of the various companies in your locality.

MR. RUSSELL: We cannot get anything from the Elko people, to whom I referred in my paper as possibly being on a commercial basis.

MR. BARNWELL: How about the Monarch and the Mount Logan?

MR. RUSSELL: The Mount Logan people have mined only a little.

MR. BARNWELL: They use about a five thousand foot tram?

MR. RUSSELL: Yes, they installed a tram and took some shale off the surface first. Then they ran a tunnel, I think forty or fifty feet, but they have operated with so little continuity, and on such a small scale, that I doubt very much if they really know what it has cost them to mine.

MR. BARNWELL: Is that true of the Monarch also?

MR. RUSSELL: Mr. Ginet told me in my office—he is the head of the Monarch—about four months ago, that he was mining at ninety-three cents a ton, if I remember rightly.

MR. BARNWELL: You mentioned in your paper the cost of mining hard coal. What does that cost?

MR. RUSSELL: Those are figures which Mr. Ede will probably be willing to give you. Most of the coal miners are keeping their costs to themselves.

MR. BARNWELL: Is it not possible to arrive at an approximate figure?

MR. RUSSELL: It is.

MR. BARNWELL: I should like to know what it is.

MR. RUSSELL: Well, now, you notice I was very careful to evade the question for the want of a set of conditions.

MR. BARNWELL: I understood that shale mining costs had been published in different statements at different times.

MR. RUSSELL: So they have.

MR. BARNWELL: Well, I don't want you to commit yourself. I simply want to know, to get an idea about the cost of mining that western shale.

MR. RUSSELL: Well, here I have protected myself with fourteen different conditions. Without all basic conditions to work on an engineer may easily make himself ridiculous.

MR. BARNWELL: All right, sir, I will do this. You pick out an ideal mining proposition and then figure on that.

MR. RUSSELL: On how many tons a day?

MR. BARNWELL: Make that as you like. I have been offered contracts at twenty-five cents a ton.

MR. RUSSELL: Give me half a million or a million dollars to open my mine, and let me produce ten thousand tons a day, continuously, and I think I can mine a certain Colorado shale bed for a dollar and a quarter a ton.

MR. BARNWELL: Thank you.

MR. EDE: (Illinois) I should like to call attention in the first place to a few things. It has been very correctly said that this industry is in its infancy and we are coming here to try to learn from the others something of the business.

CHAIRMAN ALDERSON: Mr. Ede, I think what is in the minds of the gentlemen is this: I think they would like to have you state what you think shale mining, under ordinary conditions, in a large plant, perhaps one of a thousand ton daily capacity, would cost.

MR. EDE: I could not give you the cost. I could work it out. It is not very much of a proposition to tell what it is going to cost for a ten foot seam, but when it comes to forty-nine, that is quite a problem.

MR. ALDERSON: Can you not give the gentlemen some idea as a basis, some tentative figure?

MR. EDE: No sir, I don't think it is right for you to ask me to do that at the present time, because I have not worked it out.

CHAIRMAN ALDERSON: The reason I ask that question, Mr. Ede, is that many of us who are struggling with this problem are con-

stantly asked what mining is going to cost. The financial man asks that before he puts his money in. Now, is it going to cost fifty cents a ton or five dollars?

MR. EDE: You have had your committee and you have had an opportunity to take that up. I was expecting to get that information from you. You are the party who should give me that information.

CHAIRMAN ALDERSON: I have already put my opinion in print.

MR. EDE: I don't know what it is.

CHAIRMAN ALDERSON: I do. (Laughter).

MR. RUSSELL: What did you say, Doctor?

CHAIRMAN ALDERSON: Well, once upon a time, I made a guess at it, because I wanted to be able to state something specific, even if only a guess. For our oil shales under ordinary favorable conditions, for the mining, the tramming, and the crushing of the shale, I guessed $1.85 a ton. I am on record and in print to that effect. I am willing to throw down the gauntlet if anyone else is ready to pick it up. I should like to have some other expressions of opinion. I should say $1.85 for the mining, the tramming, the crushing, and the retorting—$1.85; and with refining I put it up to $2.50. What is the use of having so many if's and and's about the matter? I am perfectly willing to make the statement I have made; and also the added statement that in my judgment, poor as it is, I think, that when petroleum well oil is in the market in the mid-continent field, for $2.50 or $3.00 a barrel, as it was only a short time ago, then oil shale plants will start. I am willing to go a little farther, and say that when that time comes the first plants that will be put up will make a fairly good grade of oil: this will be followed by skimming and cracking plants to get all the gasoline possible and putting the residue on the market as fuel oil. I am willing to make that prediction even at the danger of being all wrong.

MR. EDE: You take chances that I would not, of course. (Laughter).

I was in hopes that you had taken one certain mine and said "Here is a ten-foot seam." Then you could get at the price but you would want to know what the price of your labor was and how you were situated. All those things that have to be taken into account.

MR. RUSSELL: As a matter of fact, you cannot do any more than approximate your cost, without a set of given conditions. It puts an engineer up a tree, you know, to ask him for a cost estimate without first supplying the ground work. You might as well ask the bald question, How much does it cost to build a house as to ask how much it costs to mine a ton of shale.

MR. EDE: Exactly.

MR. RUSSELL: Awhile ago I was asked to select my own conditions. I said I will mine on a ten thousand ton basis, if you give me sufficient money to open my property, for one dollar and a quarter a ton. I may be a few cents off one way or the other. I am just making an estimate. If you give me a set of your own conditions, I may vary it. In a certain place I have in mind I will do it for a dollar and a quarter a ton.

MR. EDE: I think we have come to a place where we should take a ten foot seam—I don't know what they are, five foot or six foot, or more—but, I was going to take a ten foot seam. We have a ten foot seam in Illinois, we have put it out for forty-three cents. I don't expect you can do that, because of the labor conditions.

CHAIRMAN ALDERSON: What does it cost in Kentucky?

MR. BARNWELL: The reason I was so very deeply interested in this is because we are asked to compare the eastern and the western shales. Because the western shale is so much richer, the only advantage we have is a cheaper mining cost. As I say, I have been offered contracts

to put shale into my cars, at twenty-five cents a ton. I know that won't be possible for you in the west. My idea was only to get an approximate cost. I didn't ask for specific figures.

MR. RUSSELL: I realize that you intended to be perfectly fair.

MR. BARNWELL: I was trying to get a comparative cost between the western and eastern shales. Our only advantage arises in the fact that our shale is non-coking and very easy of access. We have the water power and everything else necessary, and the market right at our door.

MR. RUSSELL: No stripping at all?

MR. BARNWELL: Not a bit. I can scrape my foot like that and see the shale.

MR. EDE: Where are you located?

MR. BARNWELL: Between Clay City and Winchester, in Kentucky.

MR. EDE: In what state?

MR. BARNWELL: Kentucky. It is Devonian shale.

MR. EDE: How thick is your shale?

MR. BARNWELL: One hundred and sixty-four feet, but it is all above ground. It is just a quarrying proposition. A solid cliff of shale, one hundred and sixty-four feet high.

MR. EDE: What do you expect to mine that for?

MR. BARNWELL: Twenty-five cents a ton I have been offered contracts for. If they can make money at that, I can do it myself. I know that the steel mills in Birmingham claim they get their crushed limestone delivered to their furnace for thirty-five cents a yard. That is why eastern shale is such a beautiful economic proposition compared with the western stuff.

MR. RUSSELL: We can not compete with that price.

MR. BARNWELL: I hope you cannot, because we would not have a chance against your stuff. I am familiar with those western shales, and know the conditions, the lack of water, and all that. By the way, I found a little pamphlet which seems to be authentic. It is gotten out by the Colorado School of Mines. It says "Kentucky has ninety billion six hundred and four million tons of shale." Last year I had an awful struggle getting anybody to recognize Kentucky shale. This pamphlet goes on: "The known and easily worked oil shale deposits of Kentucky will yield four times as much oil as is now estimated to remain underground in all the oil pools of the United States." And the beauty of it is, that none of that shale lies under more than one foot of earth.

CHAIRMAN ALDERSON: Do you really believe that, Mr. Barnwell?

MR. BARNWELL: Doctor, I think you are very conservative. As I say, last year nobody would recognize Kentucky shale, but the doctor recently made a trip over our Kentucky deposits and knows the conditions. I was very glad to show them to him, and possibly he will admit there is some shale in Kentucky.

CHAIRMAN ALDERSON: Yes, gentlemen, I must admit that I was inveigled into going to Kentucky and viewing the deposits.

MR. BARNWELL: Were you not agreeably surprised when you got there?

CHAIRMAN ALDERSON: Yes, indeed I was. Kentucky has a wonderful deposit of oil shale.

MR. RUSSELL: I shall be very glad to answer any questions bearing on the article I have presented.

MR. EDE: Have you made any plans for operating that forty-nine foot seam?

MR. RUSSELL: That is a problem which we must study. We have not worked out a system for handling it that is altogether satisfactory to ourselves.

MR. EDE: I should like to know what you consider would be the capital required to open up a mine such as you have, to open it up and to provide it with the necessary machinery.

MR. RUSSELL: To produce how much tonnage?

MR. EDE: Well, you mentioned a ten foot seam.

MR. RUSSELL: On what tonnage basis?

MR. EDE: I don't know how much you actually require. You said ten thousand tons, before, did you not?

MR. RUSSELL: Yes.

MR. EDE: Well, suppose we take that, your own figures. What capital would be required?

MR. RUSSELL: That would depend on how far you would want to go with your initial opening up of the mine. Suppose you wanted to run three or four miles of double track tunnel.

MR. EDE: Is it your intention to go to the end of your boundary?

MR. RUSSELL: Not necessarily, but it would be very advantageous. I have in mind a certain tract of patented land. The assumption, in this case, would be that you would go to the limit of your boundary. I have in mind going back about two miles.

MR. EDE: Yes.

MR. RUSSELL: It would cost anyway from half a million to a million dollars, depending on how far you go back into your bed or seam, and upon what tonnage basis you wish to operate.

MR. ADAMS: (Ohio). I should like to ask Mr. Russell to give me information whether the oil content of the sample he mentioned was based wholly on the outcrops of shale or whether it included any of the unweathered shale.

MR. RUSSELL: They included the analysis of unweathered shale.

MR. ADAMS: Another question, whether or not the oil content was higher.

MR. RUSSELL: A very slight difference between the two. In fact, the similarity between the values in the weathered and the unweathered shale is almost uncanny.

CHAIRMAN ALDERSON: This morning at the exhibit I received a very interesting bit of information. Some of us are deluding ourselves with the notion we know all of the big deposits, especially the rich ones. A gentleman told me about a brand new one, one that was startling to me. I asked him if he would say a word to you and tell you where the new deposit is. Nobody around here ever suspected it before. I wish Mr. Wilcox would tell us about what he saw in Panama.

MR. WILCOX: Gentlemen, I want to say that I am very much of a novice in the oil shale business. I spent some eight years in the interior of Panama in looking up the resources of my company, especially of minerals and timber. During that investigation, of course, I was always keeping an eye open for coal. In Panama, of course, we have no coal, but we have a very great demand for fuel. In the course of my wanderings and investigations a native brought me a piece of rock that he called coal. Well, in my ignorance, I looked at it and thought it was cannel coal. I tried it out; it seemed to burn all right. So I looked over the place where he got this so-called coal, and found a large deposit. So I got out about a couple hundred pounds and burned it; and, as I say, in my ignorance it seemed to be coal. It left a white ash, which broke down later, and sometimes a white bone. Then I went over and looked at it again, carefully, and was able to deter-

mine the location. It lies in a valley four hundred feet above sea level, about twenty miles back from the coast, in a perfectly flat stratification. How deep it is I cannot say. I got down to the depth of nine feet, and it was still the same as it was on the top. The creeks cut through the shale. The shale area is about six miles square. I did not know much about the matter, so I sent a graduate of the Royal School of Mines from England over there to look the ground over. In his ignorance, the same as mine, he pronounuced it coal, and brought back samples of it and burned them. He said there was a supply there sufficient to supply the world for a long time to come. Then I sent a sample to Doctor B. L. Miller, of the geological department of the Lehigh University. Doctor Miller said it was oil shale of a high grade, one of the highest grades he ever saw. I found still another deposit on further east from this point, a distance about twenty or thirty miles, further up in the Cordilleras from the original deposit. How much oil shale there is in Panama I really cannot tell. I have been in different lines of work, but did become deeply interested in oil shale, because of the high oil content that this shale has, and also from the fact that the cost of gasoline and the cost of oil in Panama is running about fifty to sixty cents a gallon. My work has been along the line of copper and metals, but the doctor said you would be interested in knowing about this deposit of oil shale in Panama. I promised to say something, although I know practically nothing about oil shales.

(Applause).

CHAIRMAN ALDERSON: I think we will agree that Mr. Wilcox has made a real contribution to our knowledge. Perhaps we will know more about the Panama oil shales later.

One of the subjects I mentioned at our opening, I think, ought to be emphatically presented. The gentleman who has given a great deal of thought to the matter, and feels pretty keenly upon the subject—I refer to the fake promoters—is Mr. Hankison. He ought to tell us what he thinks about it. Mr. Hankison is a lawyer, looks into the matter with a legal mind, and feels that the industry should not be harassed by fake promoters. Mr. Hankison has a message to deliver to you.

(Applause).

MR. HANKISON: Mr. Chairman, gentlemen: I think perhaps I ought to confess in the very beginning that I have not the slightest idea of what the cost is to mine shale, so, gentlemen, don't ask me. (Laughter). I don't know as much now as I did when I started, about that question, but there is one thing, that seems to me to be of vital importance to your particular section of the American Mining Congress, and that is that we ought to profit by the examples that we have before us. Every other great industry has the fake promoter, as Doctor Alderson has well said, in his remarks. The mining industry itself has it, the oil drilling industry had it, the timber industry had it, the automobile industry had it particularly bad through the eastern states; in fact, practically everything that has ever amounted to anything, or has later been made a valid industry, has had the fake promoter. We are going to have them with us, and many of them. We are going to have them because there isn't any one single thing that I know of where we can convince the uninformed person so readily that it is a marvelous thing, that there is a wonderful future to it. I can't think of a single instance where it would be easier than it is in the oil shale industry.

Organization is going to be required. I think we may say safely at the outset that there isn't any small limited proposition that is going to succeed in the oil shale game. At least, I cannot see the possibility that a small industry of say fifty or one hundred thousand dollars, can possibly hope to succeed. I say it is going to be built upon a big scale, on a big scale all the way through. I recall that a couple of years ago down in one of the large eastern cities, some men garnered several

hundred thousand dollars, by selling stock at ten dollars a share that was absolutely worthless and in a company that had no existence whatever. That was in Philadelphia. What those men did was to send to Colorado for a carload of shale. Of course, they could show the people the results of their small scale distillation and they handed over their money. Now, what was the result of that? The result is that the oil shale industry is going to feel every lick that is hit by these fake promoters; you and all of us are going to suffer. Our legitimate enterprises are going to feel the effect, and we are going to be compelled in addition to the work of mining the deposits, to overcome this bad effect. For instance, let us say that fifty per cent. of the promotions that go out are built upon a fake plan; fifty per cent. of the promotions are built in such a way that they cannot possibly hope to succeed. That is below the average up to the present time, as far as I am informed of the conditions. That means that the legitimate enterprises have got to work doubly hard to put their proposition over and to make a success of them. That is the question you have got to overcome. Every time a man puts ten dollars into an oil shale proposition and loses it, and knows that he has lost it, he is a knocker. Isn't he? That may not affect you in your own individual shale activity, but speaking of the business, it affects every single one of us. What are you going to do about it? Naturally, that is the question. The idea is perhaps more in embryo than we should like to admit, but I can see that the eastern Better Business Commission basis is a method of handling it. By a Better Business Commission here we mean an organization that is supported by the various businesses of the local community. The mercantile houses, the manufacturing concerns, the citizens in good repute in and about Cleveland or any other community, organize a Better Business Commission. They employ a paid secretary who has all the office help necessary, for the purpose of investigating illegitimate advertising, for the purpose of investigating fake stock sales, for the purpose of doing nothing else but protecting the legitimate business and prosecuting the crooked promoters. Now, we have that in this section of the American Mining Congress—a committee on Promotion and Organization. I was appointed a member of it in Chicago last year, and I am frank to say that we have had no occasion for real work, but it seems to me that the time has arrived for something constructive. Just as sure as it is necessary to provide machinery to run our mines, so is it just as essential to set out and prosecute the fake promotions in this industry. You cannot do it individually, but you should organize in this oil shale section some kind of an investigating committee, or an authority that will do the investigating and will protect the legitimate promotions in the oil shale game. You nor I, none of us, want to take the responsibility of becoming our brother's keeper. We cannot do it individually. We, individually, have no recognized existence, but we can form ourselves into a committee, or arrange for one of a quasi public nature, which committee will have, with the consent of all of us, the right to make a report on any promotion scheme; and if it finds something that is probably wrong, that is rotten to the core, they can make an investigation, and, if this fake promotion scheme is being advertised through the mails, it can be reported to the postal authorities, or the prosecuting attorney, or the district attorney, or whatever the case may require. In other words, if a man is advertising some fake scheme through the mails, something that is wrong and rotten, something in which there is not a possibility of success under any circumstances from a business standpoint, that man should be stopped from promoting a scheme that has no possibility of success. He should not be permitted to go on. We should certainly place ourselves in a position to call the attention of the authorities to him. You see, if they are advertising through the mails, it can be called to the attention of the postal authorities. If there is a blue sky law in effect, it can be brought before the prose-

cuting attorney or the district attorney, and the promoters can be prosecuted.

Let us say, that the A. B. C. Shale Company is promoting the selling of its securities and some one wants to know something about it. We can call up the company. We are not violating the law. We have a right to do that. If we don't have the facts, we can ask the A. B. C. Company for them. If they refuse to give them we can so report. If they do give them we can investigate and tell people what we find. Now, as I say, we cannot do those things as individuals. Doctor Alderson could not take the responsibility; Mr. Russell could not take the responsibility of it; Mr. Ede could not; I could not take the responsibility of it—and none of us could, as individuals, but as an agency of this convention, we are certainly within our rights as a quasi public organization. I think that we ought to have something done along that line, on a constructive basis.

In other words, let us start out. If it meets with your approval now, by saying that this convention, this meeting is for all time opposed to the fake promoter in the oil shale industry and let us back it up by deeds and not words. I thank you. (Applause.)

MR. RUSSELL: Mr. Chairman, in the light of what Mr. Hankison had to say, I move you that a committee on resolutions be appointed by the Chair, a part of whose duty it shall be to draft some form of program as a safeguard against fake promotion.

MR. EDE: Seconded.

CHAIRMAN ALDERSON: You heard the motion as made and seconded, for the appointment of a committee on resolutions. Before I put the motion, I should like to inform you that before this conference was held there was a meeting of the men in Denver interested in this subject, and they drafted resolutions to be presented to this conference. Those resolutions will be given to our committee on resolutions for their consideration. Among them is a resolution on this very subject. It is a resolution—a set of resolutions—formulated by a group of men in Denver ten days or two weeks ago, for our consideration. I think it will be proper for this committee, when appointed, to consider them.

Another committee should also be appointed, because the officers of the Congress wish to have this conference properly organized and established, so it will be necessary for another committee to be appointed. I will entertain a motion for a second committee to be appointed on organization for the coming year.

MR. HANKISON: Mr. Chairman, before proceeding with that motion, I would move first that the decision of this meeting be that Doctor Alderson be elected chairman of the oil shale section.

CHAIRMAN ALDERSON: What harm have I done to you?

MR. HANKISON: Well, you wouldn't tell me what it cost to mine shale.

CHAIRMAN ALDERSON: I thank you for the honor, but if there is anybody else who wants the job, he is perfectly welcome to it and I will pay his campaign expenses if he will run.

MR. HANKISON: I move it be made unanimous. All those in favor say "Yes."

The motion prevailed.

CHAIRMAN ALDERSON: Thank you, gentlemen. I will entertain a motion for a second committee on nominations.

MR. BARNWELL: I move that it be appointed by the Chair.

The motion, being seconded, was carried.

The motion to appoint a committee on resolutions was carried.

CHAIRMAN ALDERSON: I should like to have a few minutes to think over the personnel before I make the appointments. This matter of fake promotions is so important that I wish some other gentlemen would give us their opinions.

MR. BARNWELL: I should like to make a remark along this line, because I have been hit a little myself this past season. If the fake promoter stays within the limit of the law, I should like to ask what steps you could take in that case? Sometimes the fake promoter will not be violating the strict letter of the law. If he remains within the exact limits of the law, I don't see what steps you can take to prosecute him. I understand that if he is operating, as you explained, without any regard for the law, he can be prosecuted, but what I am trying to find out is what steps can be taken when he stays within the limit of the law.

MR. HANKISON: This committee—

MR. BARNWELL: I just want to know about that for my own information.

MR. HANKISON: This committee, as I have stated, would have the power to go into that organization and inquire as to their property and advise the public of their findings. For instance, we will say that John Jones and Company are advertising that they have certain property located in Section 35, Garfield County, Colorado, or whatever the legal description might be; we could make an investigation of that, and if we find they are promoting a fake scheme, we can advise the public to that effect, and if they are perfectly legitimate, they will get the benefit of our investigation. If they are fake promoters, we can go to the prosecuting attorney or other official. He will immediately look that fellow up; if he finds he has no title, that he was simply selling blue sky, our work would be done by calling the attention of the proper authorities to the fakes.

MR. BARNWELL: I know. That is true enough, but suppose he does comply with the strict technical law. Suppose you go to him for information and he refuses to give it to you. You say the burden of proof is on him as to what he is?

MR. HANKISON: In other words, I think there are very few states in the Union now that do not have some kind of a blue sky law. There is not any Blue Sky Department in the country, if you please, that would dare to pass a promotion scheme without a full investigation, and they certainly would not allow a man to continue a promotion that had no possibility of success. This section could go on record as favoring a Federal Blue Sky law, enacted by the Congress of the United States. If we had a Federal Act affecting all states, we would be in a much better position to cope with this evil than we are now.

MR. BARNWELL: The entire body of the American Mining Congress is against that. Mr. Loring spoke against that last year, saying that it would be a hindrance to legitimate business.

MR. HANKISON: I think that is an overdrawn statement. In Michigan, in Ohio, in Indiana and, I guess, in Kentucky. For instance, in Kentucky you must have one-half of your stock subscribed. In Ohio and Michigan they have very rigid blue sky laws. They are beginning enterprises under these regulations everywhere. They don't prohibit industry in the least.

MR. BARNWELL: This particular chap I have in mind sold stock in Kentucky too.

MR. HANKISON: Well, those are the things in which we must educate the people.

CHAIRMAN ALDERSON: Mr. Hankison calls attention to fake property promoters. I happen to know of an instance in which a company professed to have oil shale land, but the land was not oil

shale land at all. It was ranch land in the valley. The scheme was an absolute fake. Now, a committee being asked for information in such a case needs only to say that the maps showed the land to be in the valley and not oil shale land. I have known this case, also: An engineer was employed to make a report on an oil shale property. He went to the property that was pointed out to him as the property he was to examine and report upon. But the property he examined did not belong to the man that was paying him. This engineer was smart enough to state in his report that he was reporting on the property pointed out to him by John Jones. He did not state that it belonged to the man employing him. Now, if these fake promoters can be turned over to the United States authorities, or to the prosecuting attorney, it is our business to do it. If the committee will only get hold of the facts about these fake schemes and hand the information to the authorities, it will be doing a big work.

MR. GILLESPIE: It seems heartily in accord with the business here that a committee might be appointed to find out these facts. We often see those things and we simply say, "Well, it's not up to me." Now, every member of this section should assist in this work and we could do a lot of good in running down the wild cat bunk.

MR. HANKISON: I think Mr. Gillespie has hit the keynote of the situation. If every member of the oil shale section of this congress, or any member of the congress for that matter, who learns that any company is promoting some scheme, whether good or bad, it would be well to inform the committee and let them investigate it.

MR. GILLESPIE: On the theory that it is advantageous for the good promoters and acts as a boomerang for the crooked ones?

MR. HANKISON: Yes.

CHAIRMAN ALDERSON: We have a number of other matters to discuss, but I think the committees should have some time in which to work on the resolutions and report on them tomorrow. For the committee on resolutions the Chair appoints Mr. Russell, Mr. Hankison and Mr. Gillespie; and for the committee on nominations Mr. Barnwell, Mr. Waltman and Mr. Ede.

The conference then adourned to 2:00 o'clock P. M. Wednesday, October 11, 1922.

National Oil Shale Conference

WEDNESDAY AFTERNOON SESSION

October 11, 1922.

The meeting convened at 2:15 P. M., Dr. Victor C. Alderson presiding.

CHAIRMAN ALDERSON: Gentlemen, I think we can best begin this afternoon's session by having me read a letter which seems to appreciate the situation, and is encouraging. It is from Sidney J. Jennings, President of the United States Smelting, Refining, and Mining Company.

The Chairman read the letter from Mr. Jennings (See appendix).

CHAIRMAN ALDERSON: It is particularly pleasing for us to know that we are working in the line that men like Mr. Jennings and others of his standing approve.

We appointed two committees yesterday afternoon. I will ask for a report of the Committee on Resolutions, Mr. Russell.

MR. W. C. RUSSELL: Mr. Chairman, the report which we have to present is based upon the set of resolutions which were adopted at the shale meeting in Denver on the 28th of last month. You will recall that it was a part of those resolutions that we present them to the Oil Shale Section of the Congress for approval and for such suggestion as we saw fit. We have taken the resolutions passed in Denver as a basis of this report and have really added very little to them. They are as follows:

"WHEREAS, It is the desire of the Oil Shale Section of the American Mining Congress, that the development of the Oil Shale Industry be undertaken along lines which will merit the confidence and respect of the country at large; and,

"WHEREAS, The development of said industry will depend in a large degree upon the acquisition and maintenance of unquestioned titles to oil shale lands, and second, upon the solution of the problems connected with the mining and retorting of the shale and the refining and marketing of the products derived therefrom; and,

"WHEREAS, The most economical and substantial development will be had through mutual cooperation and research in connection with the fundamental problems of the industry; and,

"WHEREAS, Fake promotion schemes have been and will continue to be a menace to the Oil Shale Industry if permitted to exist; and,

"WHEREAS, The Government of the United States can substantially aid in the solution of the various questions and problems involved in the development of the Oil Shale Industry;

"NOW, THEREFORE, BE IT RESOLVED:

"FIRST: That the various owners and holders of oil shale placer locations be encouraged to maintain and perfect their titles to the lands included in their said locations.

"SECOND: That the Department of the Interior be urged to define specifically what character of labor and improvements shall be acceptable as annual labor, and that the Department, in defining such annual labor, so define it that the work to be done will be of substantial value in the development of the property and of lasting benefit to the industry.

"THIRD: That the Federal Government be urged to provide funds which will permit the Bureau of Mines and the Geological Survey to carry on and further expand research in connection with oil shales, which is so vital and necessary to the forward progress of the industry.

"FOURTH: That the Federal Government provide funds sufficient to permit the General Land Office to re-survey those townships in the oil shale area for which the surveys have been incomplete or confusing.

"FIFTH: That every member of the Oil Shale Section, and every person interested in the welfare of oil shale be urged to use their every effort, individually and collectively, to prevent the promotion of fake oil shale schemes by reporting all organizations of any kind entering the oil shale field to the Promotions Investigating Committee, and to assist in the prosecution of persons violating the laws and furnish all possible data to those departments of the Government charged with the prosecution of such cases; that the Promotions Investigating Committee be authorized to collect, receive, and dispense all data in connection with such schemes as may be reported, and said committee shall make thorough investigations based upon any such reports, and make suitable recommendations to the proper legal authorities."

This report is respectfully submitted, and I move its adoption.

The motion was seconded.

CHAIRMAN ALDERSON: It is moved and seconded that the report in the form submitted be adopted. Have you any remarks before I put the question? There is reference in those resolutions to the work of the Geological Survey. I am wondering if that resolution meets with the approval of Dr. White?

DR. DAVID WHITE: No disapproval, at least. It is quite agreeable.

CHAIRMAN ALDERSON: Are there any further remarks on these resolutions as offered?

If not, those in favor of adopting the report of this committee, which consists of these resolutions as read, will please signify it by saying "aye"; contrary-minded? They are adopted.

A subject that is of very great importance in this work, gentlemen, and on which a great deal of experimental work has been done, and about which we know as little as about any phase of the work, is that of retorting. I would not say that retorting is the most important part of this industry, but it is an exceedingly important part. I have asked a gentleman to give us his views of the most acceptable methods to be applied in retorting shale as we know it today. Mr. Newbery.

MR. J. S. NEWBERY: Mr. Chairman and Gentlemen: I just want to give you a short description of the retort I have designed. Our large plant is of 250 ton daily capacity; and continuous in operation. The shale is fed in from the top of the machine under an air tight seal, and dropped through a worm feed on the top deck. There are ten decks in this machine; the shale is carried around on a rotary deck on which are twenty-four agitators or rollers. The shale makes a complete circle in the deck, until it comes to a hole in the deck and is dropped through on to the next lower deck, where the shale is again carried around a complete circle; this operation is continued until the shale passes through ten decks and finally reaches the bottom. The heat is in the center part of the machine, heating under the decks. The gas is taken off from the first at a temperature of 450 to 950 degrees. The gas is being drawn off under a vacuum the whole time and spent shale dropped into the receiver at the bottom of the machine.

CHAIRMAN ALDERSON: Mr. Newbery, why, if I may ask, did you take the vertical type rather than the horizontal?

MR. NEWBERY: Because I figured that you can heat the vertical type with the center heat easier than you can the horizontal type. Most of the machines are heated from the outside at the present time.

CHAIRMAN ALDERSON: Are you quite sure that your retort is not too complicated, with too many moving parts, to run along smoothly day after day, week after week, and month after month?

MR. NEWBERY: I have only one moving part in the center of the machine. The feeds are the only other moving parts on it.

MR. RUSSELL: In case of repairs, how do you remove the shell?

MR. NEWBERY: Just lift it off completely. It is built in three parts. It has a water seal at the bottom and all you have to do is to lift the heat shell off.

CHAIRMAN ALDERSON: Then you would have access to all the scrapers at once.

MR. NEWBERY: To all the scrapers.

MR. S. E. BARNWELL: Supposing one of the center scrapers broke; you would have to tear down your entire rotation section to get at that, would you not?

MR. NEWBERY: The rotating case is in sections and on the large machine they are bolted together; you can take them apart and get at any point. This is the rotating case here, without the outer case, and it just shows six of the scrapers or rotors; this revolves like that (demonstrating). There is an outer case outside of this again. This is your rotating case, and you have an outer shell on this again, which is your seal for your gases. As they pass under the hopper, they fill and rotate your case and agitate it and pass around until it fills, and it passes around ten times into each one of these decks. This shows just two decks, and there are twenty-four of these rotors. This is entirely enclosed by an outer vacuum wall case. Your gases are taken out over the top. Your outer case encloses it.

COL. J. A. EDE: What comes through the slit on the side?

MR. NEWBERY: That is just to show the working.

MR. RUSSELL: I thought you said, in your remarks a few minutes ago, that the gases come off the top.

MR. NEWBERY: Yes, up over the top.

CHAIRMAN ALDERSON: What are the dimensions of one of these commercial scale retorts?

MR. NEWBERY: Twenty-six by eleven foot six.

CHAIRMAN ALDERSON: What would be the daily capacity?

MR. NEWBERY: Two hundred fifty tons. We have a five ton unit in operation at the present time, which is really a small commercial size.

MR. BARNWELL: How are you supposed to sell the commercial size unit?

MR. NEWBERY: A commercial sized unit would cost about $35,000.

MR. BARNWELL: Is there any royalty attached to that? How would that be handled?

MR. NEWBERY: We haven't gone into the royalty matter yet,

MR. BARNWELL: Last year I was a member of the Educational Committee. I have always made it a point, so far as possible, to try to investigate anything I hear of that is new in the retorting line. I have seen either the actual retorts or the prints of practically everything that is operating in the country up to date. I have heretofore held out for a machine which would also produce ammonia from the Kentucky shales. This machine, in my opinion, will produce the oil so cheaply that ammonia can be considered a negligible product on account of the cheapness of operation and the low installation cost of the machine. We checked the thermal efficiency of it. It retorts a ton of shale, even on a small sized unit, with 550,000 B. t. u's. That is as low as any actual operation that I have heard of yet; and it does that because it is entirely internally heated; there is no waste at all; losses are all taken up by the shale itself. You can hold your hand at any time on the outside jacket of that machine. The retort I started to install in Kentucky was an

Americanization of the Scotch type, because I expected to recover the ammonia; but it is an expensive installation per unit; in other words, a retort to handle seven tons of shale would cost me in the neighborhood of $25,000. This machine, for $35,000 could handle 250 tons of shale in the same time. Five hundred and fifty thousand B. t. u's. are required to reduce 250 tons of shale in this retort. The analysis shows that natural gas runs in the neighborhood of 1100; we checked the time from the meter, how much gas went through and how much shale went through, and we used nine hours for 1000 feet. In checking back the B. t. u's. it checked exactly 550,000 B. t. u's. per ton.

DR. WHITE: Is there no condensation before it gets out of the upper deck?

MR. NEWBERY: There is no condensation at all. My gases are taken out with a vacuum. We have probably had the machine open a dozen times to check up on that, to show people who thought there would be condensation.

DR. WHITE: Are the gases at the different temperatures drawn out at the top in a single stream?

MR. NEWBERY: Yes.

CHAIRMAN ALDERSON: What size do your crushers take?

MR. NEWBERY: From one-half inch down.

CHAIRMAN ALDERSON: Won't the shale drag on the bottom of the decks and form a layer that will cause trouble?

MR. NEWBERY: Not the way I have these scrapers set. They are so arranged away from the deck, that they keep the shale rotating and agitating all the time. They leave some of the shale under the scrapers, and when the bottom part is scraping away, it must roll; the next turn might take a little bit and leave a little bit. We prove that before it gets around half way every bit of the old shale is gone from the first scraper.

DR. WHITE: Might I ask which shale you find to work most satisfactorily in your retort?

MR. NEWBERY: At the present time we have been running through our Kentucky shale; we are getting some from Colorado, and there is some coming in from Pennsylvania that we are going to put through. I have designed this retort for handling any of the shales. If it was only Kentucky shale you wouldn't need all those agitators.

DR. WHITE: Don't you use at Clay City the zone that is about 70 or 80 feet above the Onondaga limestone? I was down there last June and I had a notion that they discarded the upper part of the black shale in the quarry and used that principal bench which is about 15 or 20 feet thick, possibly embracing a coaly zone, incidentally, on the main level of the quarries.

MR. BARNWELL: I have probably done as much as Mr. Newbery has down there. The top of that shale runs very slightly in excess of the particular layer you speak of.

DR. WHITE: But it isn't used.

MR. BARNWELL: Yes, sir, it is used. There will be no discarding at all. There is one layer in that shale, of four and one-half feet, which doesn't work. The streak you speak of is above the streak you thought he was working.

DR. WHITE: There is a good streak in the upper part of the black shale.

MR. BARNWELL: Yes.

DR. WHITE: I don't think that is caught in this quarry.

MR. BARNWELL: We don't get it in our place at all. It is all uniform, except that one streak, but it isn't a shale that calls for any-

thing special in the treating. It just goes through your retort and passes out as waste.

MR. RUSSELL: Do you use superheated steam?

MR. NEWBERY: The retort may be used with superheated steam, but we don't use it.

MR. RUSSELL: Do you get a better grade of oil by not using superheated steam?

MR. NEWBERY: In this particular type, I will say since leaving out the superheated steam we have had a better grade of oil.

CHAIRMAN ALDERSON: In Scotland they told me very emphatically that they wouldn't think of trying to handle the shale without superheated steam; they wouldn't think of it for a minute; it was impossible to do without steam and get any oil at all that was worth while; and some experimenters here have claimed that they got more and better oil by using superheated steam.

MR. RUSSELL: It is the experience of our chemists on the Colorado shales that they get about 10% higher recovery by the use of superheated steam than without.

MR. BARNWELL: In what type of retort is that?

MR. RUSSELL: You mean the one that they use the superheated steam in?

MR. BARNWELL: Yes. Steam in the vertical retort cannot come in contact with the shale; that is the point I am trying to make.

MR. RUSSELL: I can't tell you as to that, but in that type of retort they are using an oil company's experimental plant.

MR. BARNWELL: The doctor's question in relation to Mr. Newbery's retort as regards the steam is that while his is a vertical retort, the steam would have the same action in passing over the surface of the shale as you would get in an ordinary horizontal retort; in other words, you don't get your steam shot through the shale pack as you do in a vertical retort similar to the Scotch shales.

CHAIRMAN ALDERSON: They told me there they used the steam, of course, to recover the nitrogen and make ammonium sulphate and then they also added in a true Scotch way, "To sweep the vapors through and clean out the retort."

MR. NEWBERY: When you use a column of shale you can't get the gases out very well unless you do that.

CHAIRMAN ALDERSON: What provisions have you made to control the heat in this retort?

MR. NEWBERY: We can adjust our burners almost to anything you want to and we can change our speeds, our time, our feeder, anything practically you want to do in a very few minutes. If you want to treat a different kind of shale and it takes a little longer, you change your feeder and change your speeds.

MR. RUSSELL: What is the normal length of time that you occupy in putting through a given quantity of shale?

MR. NEWBERY: Forty-five minutes from the time the shale goes into the top until it falls out into the bottom. It is not intermittent but continuous.

CHAIRMAN ALDERSON: Have you varied the length of time in transit for a particular bit of shale, so as to know what the variation would be in the character of the oil and gas and the amount, if the time is lengthened, or if the time is shortened—I mean the time in transit?

MR. NEWBERY: We are experimenting along those lines now. I cannot answer what the results will be at the present time. We have

varied the time on the complete run, but we have not varied our heats at different times.

MR. RUSSELL: Have you figured out your per ton cost for retorting?

MR. NEWBERY: It runs at about twenty-five cents a ton.

CHAIRMAN ALDERSON: Twenty-five cents a ton for the retorting alone? On how large a plant?

MR. NEWBERY: In the two hundred fifty ton units.

CHAIRMAN ALDERSON: Now, gentlemen, if we could just get some figures on the cost of mining and crushing and add twenty-five cents to that (laughter) we may get somewhere before we get through.

DR .WHITE: This Kentucky shale ought to crush very much easier and cheaper than the Colorado shale.

MR. S. E. BARNWELL: Mine is cheaper.

MR. NEWBERY: Very much easier.

CHAIRMAN ALDERSON: I wish somebody would take that matter in hand and do a little figuring and give a guess before we separate. We had a controversy yesterday afternoon about the cost of mining and retorting shale, and we didn't get anywhere.

MR. QUINN: Mr. Newbery has made an estimate of the cost on our Kentucky property, and can probably give you some idea. He is an engineer.

CHAIRMAN ALDERSON: I wish we could get some figures, gentlemen, if nothing more than a preliminary estimate: Will somebody do some figuring on this? Won't you, Mr. Gillespie?

MR. GILLESPIE: That would be seventy-five cents to the ton, on crude oil.

CHAIRMAN ALDERSON: On Kentucky shales I don't think in the long run you will be able to get more than half a barrel of oil a ton. That would make a dollar and a half a barrel. I think we will get somewhere, gentlemen.

MR. RUSSELL: Have you your plant in the field?

MR. NEWBERY: We have it in Buffalo. We are getting one ready to put up in Kentucky.

MR. RUSSELL: How long have you run it continuously at one time?

MR. NEWBERY: I think we had a four day continuous run. The trouble really on the continuous run is that we are in Buffalo and our shale is in Kentucky, and it is a pretty big problem to get shale down there to make a continuous run at the present time.

MR. RUSSELL: Have you attempted to any extent to refine the oil you produce?

MR. NEWBERY: We haven't done any refining. We have a chemist with us who has been specializing in that work.

MR. RUSSELL: You really don't know in what shape you are getting your oil. Whether it has been cracked or not?

MR. NEWBERY: Yes, our chemist has gone into that and he says we are getting a good grade of oil.

CHAIRMAN ALDERSON: Do you know the percentage of unsaturated and saturated hydro-carbons?

MR. NEWBERY: I think you had better call on Mr. Barnwell.

MR. BARNWELL: Let me ask you what difference it makes?

DR. WHITE: Did you state your maximum temperatures?

MR. NEWBERY: Four hundred fifty to nine hundred fifty is what we run on this Kentucky shale. It might vary a little in the different shales, but that is easily taken care of in the machine.

MR. RUSSELL: What do your analyses show in unsaturates?

MR. BARNWELL: Mr. Russell, for the past year I have been trying to get somebody to tell me what unsaturated meant in shale oils. I wrote to various agencies and I haven't found anybody yet—

CHAIRMAN ALDERSON: Go down stairs to the Colorado School of Mines exhibit and you will find a pamphlet by our Dr. Low which will tell you.

MR. BARNWELL: I have a personal letter from Dr. Low on that subject and he tells me about the oil, chemically, but he does not tell me what they mean in the finished product, and that is all we are interested in.

CHAIRMAN ALDERSON: I don't mind making a try at it, myself.

MR. BARNWELL: I believe if we get some oil first and see what we can do with what we have, then dig into the chemistry of the thing, we will accomplish something. It certainly is up to us to get some liquids first and give the chemists something to experiment with, rather than on the shale. The chief objection seems to be that the unsaturates cause terrific loss in refining. That is undoubtedly true as applied to crude petroleum as it comes from the ground, but Dr. McKee's and Prof. Botkin's experiments indicate that the cracking of the shale oil does not produce unsaturates. I am not a chemist, I am simply a construction engineer, but when I want this chemical knowledge I go to the very best sources that I know of, which are available, and that is the information I have been able to obtain.

MR. RUSSELL: Running normally, Mr. Newbery, what is the specific gravity of your oil product?

MR. NEWBERY: About 38 degrees Baumé.

CHAIRMAN ALDERSON: Perhaps Mr. Edwards would like to take up that question of saturated and unsaturated hydrocarbons.

MR. RUSSELL: That is a very much lighter oil than we are able to produce in our experimental way in Colorado; we run about 26 degrees Baumé. What is the percentage of your coke residue with respect to the oil? How much oil have you got out of your shale? How much oil can you produce, commercially, out of 27 gallons of fluid that comes from your retort?

MR. BARNWELL: About 94%.

MR. RUSSELL: Yes. That answers in a way the unsaturated hydrocarbon question.

MR. BARNWELL: No, I don't think it does. (Laughter) Do you?

MR. EDWARDS: I don't know as I can answer that to your satisfaction. I am pretty new in the game and I came here to learn and to listen more than to say anything. I was interested, however, in the discussion on the superheated steam proposition in the Scotch retort on shale in comparison with our American practice. I think there is this one additional point that might be brought out in that connection: As well as being used in Scotland for the purpose of recovering the nitrogen products and the ammonia, and in addition to the sweeping of the produced gases and light oils from the retort before they are cracked, I think it has the additional factor of keeping a steady temperature, holding it from running up to excessive heights. I think the superheated steam has that influence on the temperature control of the retort, which is also a beneficial one. With regard to the percentage of saturates and unsaturates, we have not gone into that to any extent. My notion of the thing is that the saturates are not at all detrimental to the finished product. Possibly it requires some considerable study to know how to refine a product that has a high percentage, 40 to 45%, of unsaturates in it, and a different process of refining from that of the well oil product, but I do not think it is insurmountable. Once we are able to do that without the loss of this 40 or 45% of unsaturates and get by

with it, the finished product is as good as the gasoline from the well oil products, and possibly better. It has an elasticity to it, as I understand it, that is not inherent in the well oil gasoline. I don't know whether that answers the question or not.

MR. G. L. ADAMS: I don't believe that, to date, there has been enough distinction made between the low temperature and high temperature carbonization processes. There has been much adverse comment on any proposed process requiring the use of cast iron or metal on account of buckling, warping, in general not standing the heat. I should like to ask whether your retort has been under operation for a sufficient length of time to give any test of how it stands up with the temperature that you require?

MR. NEWBERY: We have run the test up to 1260 with no warping whatever.

MR. BARNWELL: How high does the temperature run in the MacDougal ore roasters?

MR. RUSSELL: I can not tell you; I don't know. We spoke a few minutes ago with reference to the amount of B. t. u's. necessary to produce certain results. About your non-condensible gases. What percentage of non-condensible gas that you may use in your retorting do you recover from each ton of shale? In other words, how much gas have you got to buy, or how much oil have you got to use, or how much provision for heating aside from the non-condensible gas which you are producing right along, must you make in order to operate your plant?

MR. NEWBERY: If I may, Dr. Alderson, I should like to have Mr. Edwards answer that question. He has gone into that and can answer it better than I can.

MR. EDWARDS: The amount of work we have done and the figuring that we have gone into on the subject I imagine would show that we can supply all the gas we need for our own fuel. I think there is in our Kentucky shale between 29 and 30% of combustible material, and of that 29 or 30% two-thirds are available for gas and oil—approximately; one-third of it remains in the refuse as coke. The problem, in my mind, is not to find out whether we can get enough gas to operate the retort, as a fixed gas that cannot be condensed, but I am terribly afraid we shall produce too much. That is the way it strikes me. My notion of what is desirable is to produce just the least amount of gas possible; if we could assure ourselves that we could not produce enough gas to operate our retort, I would feel very happy indeed. I am afraid we shall have to produce enough gas to operate our retort. That is my stand in the matter.

MR. BARNWELL: I can give you an exact figure on that from a test made specifically for the purpose. The Detroit Laboratory ran a test for me, to determine the quality of the gas, and the amount of gas involved in the normal reduction process, and this particular retort gives more than enough to operate. As I explained a while ago, Mr. Newbery's retort requires 550,000 B. t. u's. to the ton.

MR. RUSSELL: What percentage of sulphur do you find in your oil?

MR. BARNWELL: Eighty-six hundredths of one per cent.

MR. RUSSELL: You have covered that, have you not, Dr. Alderson, in your report on Kentucky shales?

CHAIRMAN ALDERSON: Yes. I don't recall the figures at this moment, but they are there. I wish to make one observation, for fear one matter may not be clear. If I am wrong in what I state, I hope some chemist will correct me. The question of saturated and unsaturated hydrocarbons was left hanging in the air. I should like to state the matter as I see it. If I am wrong, I wish, as I said, to be corrected. From the point of view of a man on the fence, this is the way it looks to me.

The unsaturated hydrocarbons in the oil are the hydrocarbons in an unstable chemical condition, and, if left in the oil, they break up and form new compounds which cause a discoloring of the oil or offensive odors. Consequently the unsaturated hydrocarbons are not wanted. The unsaturated hydrocarbons in the Scotch oils run between 50 and 60%. In one test of well petroleum, made at the school, the percentage was 23. In the refining of the ordinary well oil today, the practice is to use sulphuric acid and caustic soda to remove these objectionable unsaturated hydrocarbons in order to get a clean, sweet smelling oil that is not objectionable. By using the acid and caustic soda treatment they eliminate these unsaturated hydrocarbons, which are a dead loss. The Scottish method is to use the acid and soda and, as the old gentleman said to me, he just throws in enough to bring out what he thinks will be the right product and lets it go at that. What that right amount is depends upon how the old man feels. (Laughter). In this country the refiners have claimed that they could not refine the shale oil because the loss would be so heavy. In tests that we have made at the Colorado School of Mines on our shale oils, these unsaturated hydrocarbons will run from 60 or 70 to more than 90 per cent. Naturally the oil refiner today will say, "Well, we can't handle that stuff; the loss is too great." The real problem that is going to face us, then, is a method of refining our shale oil so as to change the unsaturated hydrocarbons into a more desirable form—the saturated hydrocarbons—through a method of refining that will not be along the old lines. That is the way I understand the matter. If I am wrong I should like to be corrected.

MR. BARNWELL: Do you remember Mr. J. C. Howard, who spoke last year; he was a refiner, wasn't he?

CHAIRMAN ALDERSON: Yes.

MR. BARNWELL: He said the refiners were perfectly able to take care of any oil given them if it was given to them in sufficient quantities to justify their taking care of it. He said, "If we have to change our methods to refine shale oil they will be changed, when you give us sufficient shale oil to refine." Mr. Howard made that statement last year at the Congress.

CHAIRMAN ALDERSON: I think the refining of the oil will be taken care of, but not necessarily according to the methods in vogue in the commercial practice today. Can anybody add anything to what has been said or find fault with it?

MR. E. S. PORTER: I think you are entirely right about the refining matter. It will not be a sulphuric acid refining, as we know it now, to refine shale oil. It may be a sulphuric acid refining, but not of the strength we use now. I should like to ask Mr. Newbery if there is sufficient grinding action as these knives move about the deck, so that you have a dust problem in the oil recovered, since you remove it by vacuum?

MR. NEWBERY: The knives on here do not touch the deck at all. There is no grinding problem with the shale.

MR. PORTER: But there is bound to be some dust, for instance, at the lower deck.

MR. NEWBERY: We have had no effect at all like that in our oil.

CHAIRMAN ALDERSON: We have Mr. Newbery still on the witness stand, as it were.

MR. RUSSELL: What is the highest grade shale you put through your retort·

MR. NEWBERY: We haven't run much of any shale except Kentucky, Mr. Russell.

MR. RUSSELL: I am wondering how those baffles would run on very rich shale; there is the possibility of some freezing, coking, or gumming.

MR. NEWBERY: We have run tests with the small equipment we have. If you keep it agitated it won't coke at all, but the minute you let it stop, even for a little while, it is likely to coke.

MR. RUSSELL: It is like the retorting in the simple assay. If you allow your heat to go down it is likely to '"freeze." I was wondering how far you had experimented along that line.

CHAIRMAN ALDERSON: Mr. Newbery, do you plan to put in a refinery and put on the market all the products of shale oil that you can manufacture?

MR. NEWBERY: No, sir.

CHAIRMAN ALDERSON: What are you going to do?

MR. NEWBERY: Manufacture gasoline and fuel oil.

CHAIRMAN ALDERSON: Why?

MR. NEWBERY: Becase I think there is more money in just handling those two products and eliminating all the other by-products. Those are the two things for which there is a large demand today.

MR. RUSSELL: I am glad we have found a retort inventor who is not going to manufacture at least three hundred and seventy-five different products the first few minutes of its existence. I think we are getting somewhere.

CHAIRMAN ALDERSON: I don't like to be kept out of this discussion just because I am in the Chair. I asked that question, because sometime ago in Boston, I met a gentleman from Canada at luncheon. We were talking over this matter and he made this statement: "I am in the business of importing crude oil from Mexico. I sell it to the Canadian Pacific Railroad Company for fuel oil. Now", he said, "What I want is a simple retort. At Moncton, New Brunswick, only four miles from tide water, there is a big deposit of oil shale. I want a retort that will handle that shale and turn out, in large quantities, crude oil. Then I want a skimming and a cracking plant, to get all the gasoline I can from the oil. I have a big market for the gasoline at top price. Then I will turn over to the Canadian Pacific Railroad all that is left, as fuel oil." I said, "There is a great business in that for you?" He replied, "Yes, there is a fine business in that for me, and that is what I am after."

DR. WHITE: I should like to ask if Mr. Newbery has looked for or tried out carbonaceous shales, possibly as good or better at some point near Buffalo.

MR. NEWBERY: We are getting some shale from points nearer than Kentucky. I think that in ten days they will be tried out.

DR. WHITE: I asked that question because the Geological Survey has traced the oil shale through Chillicothe and Columbus. It underlies the city in which we now are. From the looks of your outcrops there is some shale west of Chillicothe and on the Huron river, that might possibly do as well as the Kentucky shales. About four or five miles northwest of Norwalk, which is about an hour's ride by trolley from Cleveland, the outcrop looks fairly rich and might be worth while testing. Outcrops are also lower on the Huron river, near Lorraine and also in bluffs on points along the lake. There are doubtless other outcrops in which the shale is fully as rich and which I have not seen my self. Your black and carbonaceous shales in western New York, within twenty-five miles of Buffalo, are probably somewhat more devolatilized by geological processes and although they might look as rich and might, originally, have been as rich, they are hardly likely to give you as good values as those in Ohio and Kentucky.

MR. NEWBERY: Three gallons is the best we can get out of New York state shale.

DR. WHITE: I think that the observation of the gravity of your oil is a very interesting one. The black shales of Kentucky and Ohio—we will call them oil shales, if you please—are older, have been subjected to more advanced action of geologic processes and have lost more or less of the volatile matter which they originally had. Whether as the result of cracking, or whatever the original causes may be, the natural oils in the same formations are of higher grade. It is quite logical and natural to expect from the shales of that rank, which is bituminous in this case, other things being equal, a higher grade distillate. The Colorado shales contain elements of different ingredient matter and probably some different compounds from those of the Kentucky shales; and by the same token it is most unlikely that the process which will work more successfully on the Kentucky shales will surely and consequently work better on the Colorado shales.

MR. BARNWELL: I believe I can give Dr. White some information on those two particular shales he mentioned. One outcrop is on the Vermilion river. Is that the outcrop you speak of? There are three beautiful bluffs about six miles back from the lake on the Vermilion river. That shale runs nine gallons a ton. I took forty samples of it. Mr. Felton, of the Pure Oil Company, who made a very extensive investigation of the shales through Ohio, said the best he ever got was fourteen gallons. I have often gotten as high as twenty to twenty-one.

DR. WHITE: I was judging purely on appearance.

CHAIRMAN ALDERSON: Gentlemen, have you any further questions to ask Mr. Newbery, or anything further to contribute on this subject of retorting? Before leaving this subject of retorting I wish to make one observation: The Scotch retorts, vertical in shape, have been tried in other parts of the world, notably in New South Wales, and they have been failures. The reason I think is partly this: In the Scotch retort the shale goes down through the retort very slowly; virtually twenty-four hours is taken for a bit of shale to pass through. The Scotch shale notably runs low in oil. The Scotchman and the Englishman and the rest of the Britishers reason thus: The Scotch retort handles the oil shale in Scotland; ergo, the shale in New South Wales will be properly treated by a duplicate of the Scotch retort. The trouble with that reasoning is that the Scotch shale will run only a little more than twenty gallons to the ton and the best of the New South Wales runs one hundred and forty. Put shale that will run one hundred gallons or more to the ton in one of those Scotch retorts and let it stay there overnight and you have to use a hammer and a chisel to get it out. That failure occurred in New South Wales and in Colorado in the early days. That brings me to the second reflection: The question as to whether as a general type the vertical retort will succeed with the higher grade of shales. Will not some retort of the horizontal type be a success—because the shale can be passed through very rapidly and the heat control may be made perfect? Perhaps a successful horizontal revolving retort will also handle our very rich shales. Or still broader, will there not be a new form, or some new forms of American retorts, developed to handle our varieties of American oil shale

MR. BARNWELL: Doctor, I have one criticism of that: When you speak of a vertical retort, do you mean a vertical retort which carries a solid column of shale?

CHAIRMAN ALDERSON: I mean the vertical type of retort, Mr. Barnwell.

MR. BARNWELL: For instance, Mr. Newbery's retort is a vertical retort but the objection which pertains to the Scotch retort does not pertain to his. I just wanted to differentiate between the different types of verticals, that was all.

CHAIRMAN ALDERSON: I am just dividing the retorts into two large classes, the vertical and the horizontal.

MR. BARNWELL: Mine had a shale column through it; that was an ammonium machine primarily.

CHAIRMAN ALDERSON: There are a number of varieties of the horizontal retort. Is there anything further to be said on this subject, gentlemen?

MR. T. E. STEINER: Is there any virtue in the residuum of the shale after the oil is taken out?

CHAIRMAN ALDERSON: You mean the spent shale?

MR. STEINER: Yes, sir.

CHAIRMAN ALDERSON: I was given some of that spent shale once and was told it made an excellent tooth powder. (Laughter).

MR. EDWARDS: There have been speculations upon it as a road builder and as a basis for Portland cement, and various other uses, but aside from those that are entirely irrelevant to the shale oil business itself, there are two important products. In the first place, the nitrogen products come off at higher temperatures than do the gases and oils and by a subsequent treatment may yield ammonium sulphate. The other one is this: If we have left in the spent shale ten per cent of carbon, you can install a water gas machine by which you can produce, in an incandescent state, the carbon monoxide and hydrogen for fuel, for power, and for heat in your retort. I think there are still values left in the spent shale that are also worth considering.

CHAIRMAN ALDERSON: The Chair would like to throw out this question as coming from your query about what there is in the spent shale. Has anybody found any gold, silver, or platinum in their shale?

MR. RUSSELL: Small values in gold and silver are sometimes found, particularly if the shale is heavy in pyrite. I say small values—traces of gold, perhaps twenty cents; silver, fifty cents. We freqently find in certain strata those small values in the Colorado shales.

MR. BARNWELL: The expense incurred would probably be prohibitive, would it not?

MR. RUSSELL: Absolutely, as far as our tests have gone.

CHAIRMAN ALDERSON: Are there any further questions to be asked of Mr. Newbery? If not, he may be excused from the witness stand.

CHAIRMAN ALDERSON: Before we continue with other topics, I wish to read a letter from a gentleman whom you all know by reputation, a man who gives us the latest word on the practical side of this subject, Mr. R. M. Catlin, of the Elko plant.

... The Chairman read the letter from Mr. Catlin (See appendix).

CHAIRMAN ALDERSON: As an explanation, I would say that Mr. Catlin's plant at Elko, Nevada, is now in steady commercial operation.

MR. BARNWELL: Are there any statistics showing the amount of oil production in America—of shale oil?

CHAIRMAN ALDERSON: No, there isn't enough yet to form any statistics; that is the trouble. Mr. Catlin's plant is the only one that is doing anything on a commercial basis. Other plants have run intermittently and produced a little, but not enough to dignify them with the name of statistics, I think. Is there anything further that may be said on this subject of retorting? Mr. Gillespie, I wish you would be good enough to give us those figures that you worked out, and let us have them as a matter of record. I feel as though that was a "home run."

MR. GILLESPIE: All right, I will do that.

Estimate.

Mining	$0.25 a ton
Crushing	0.11 a ton
Retorting	0.25 a ton
Overhead	0.14 a ton
Total	0.75 a ton

CHAIRMAN ALDERSON: Aside from the subject of retorting and refining, there is a subject that comes before that—the prospecting and the testing of the oil shale land itself. There are various ways of going to work, but there is one way which is a distinctly scientific, thorough, and exact method. I think we should like to know just the features of that and why some of us think that it is the best method. I am going to ask Mr. Hollems to say something on the subject.

MR. HOLLEMS: Obviously, it would seem to me that the Diamond Core drill would be the most satisfactory, and the surest method of prospecting the oil shales. You may find that in sampling your core you get a considerable difference from what you find in sampling an outcrop. It seems to me that the first thing to do in the development of an oil shale property is to drill it thoroughly with the Diamond Core drill. The shales vary in their content through the different strata, not so much, perhaps, in the Kentucky shales as they do in the western shales. Then, again, you should know the thickness of these strata and the dip if any, and also the areas. What apparently might be a big body of shale might extend but a short way back until it is cut off by a fault or a big dike. I shall be very glad to hear from any one present who has done any Diamond Core drilling in the oil shale fields and what were the results of the samples taken. I have been told by a chemist in Indiana, that on a one hundred ten foot core he found a variation of fifty per cent in fifty feet of the core. He still had fifty feet to sample before making the complete report on the whole core from top to bottom.

MR. BARNWELL: Did you start at the bottom or the top to get that sample?

MR. HOLLEMS: I couldn't say, Mr. Barnwell.

MR. BARNWELL: If he started at the bottom I can see it. If he started at the top I can not.

MR. R. J. WALTER: Doctor, did you get the figures of one company —I don't know the name, but it did considerable core drilling on shales near Glenwood Springs? I know Mr. Nice, a chemist had charge and made the tests on the oils. I was wondering whether you heard or got the results.

CHAIRMAN ALDERSON: They have been promised me, Mr. Walter, the same as the results of the core drilling by the Ventura company, but I have not received them. I am watching for them, and I will make good use of them whenever I can get them.

MR. HOLLEMS: It seems to me, from an economic standpoint, that Diamond Core drilling would be the first thing to do, in order to have a sample. I am connected with the H. R. Ameling Prospecting Company, of Rolla, Missouri, and last year we were drilling in Wyoming. We contracted with a concern to do considerable drilling in the coal fields. This concern was a new corporation, I might say, that held extensive holdings, and had had some churn drilling done. They had every belief that they had a large body of coal at this particular point, and the churn reported fourteen feet of coal. After we had done some Diamond Core drilling for them they became doubtful of the correctness of the report and we bored a hole for them just three feet from the churn drill hole. We went down some little depth greater than the churn driller had gone and we found less than fourteen inches of coal in the hole. There

was black shale and bone, and here and there, there would be an inch of coal interspersed. Before we did this drilling for them they were just on the point of sinking shafts, at great expense. Of course, this core saved them a great loss of money. So it would seem to me that in the case of the oil shales, that first thing to do is to procure your core and have it carefully tested for the oil content.

CHAIRMAN ALDERSON: I think before we leave this matter of retorting and refining, we should hear a word from a gentleman who, perhaps, knows more about it than all the rest of us. Mr. Gifford is here. I wish Mr. Gifford would say a few words on this subject. Mr. Gifford. (Applause).

MR. GEORGE P. GIFFORD (New York): Gentlemen, as the old speaker says, "This is rather unexpected." I came into Cleveland this morning on another matter of business and had no thought of the convention here, or of any meeting that might be interested in oil from shale. However, we have all got to recognize the fact that it won't be long before shale oil must take the place of the present well oil. While the oil supply is large and ample at present, I have lived long enough in the business to know that it has some tremendous fluctuations, and the next fluctuation downward in the supply of oil will have to be met by the product from oil shale. Now, we have known of oil shale for many years. We know that it is distributed all over the country, covering many areas. We know where it is. We know where it is the richest. We know what oil can be obtained from it. The question to my mind is so simple that I don't think there is anything to it but economy. In other words, the man that devises a method of taking the oil out of the shale cheaply is the man that will produce the oil. The place to refine it is right where it is made. In other words, crude oil as crude oil will not stand high freight charges; it won't stand long distance railroad hauls. When it is produced in quantity, making it of sufficient size to warrant pipe lines, yes, it can then be transported by a pipe line; but in its infancy, I believe it should be refined at the point of production, and the only thing that I can see in the oil business, looking ahead, is gasoline. Never mind any other products. If we can get them, well and good. If we can manufacture them economically and produce products that are now produced from crude oil, we will meet that situation when the time comes. But I believe the time is right here today when shale oil can be extracted and cracked into gasoline and handled along economic lines. and money can be made out of the business, and that is what is on everybody's mind, "How much money can I get out of it?" That doesn't bother me. What bothers me is, can we cheaply and economically make it? The handling and refining of oil is very simple. There isn't a great deal to be said on the subject. There are processes for cracking oil into gasoline. With the increased use of the motor truck, the farm tractor, the bus business which you see being added to every day, and in a small way for airplanes, comparatively speaking, the market for gasoline is going on and on and today we can barely produce, with the tremendous amount of crude we are getting, gasoline enough to keep us going. The increase of it is fifteen to twenty-five per cent every year, and it goes on like compound interest. I have gotten to an age where it seems to me that there is nothing in oil today but gasoline, more gasoline and then some, and the source from which it is going to be supplied is shale oil, as I said a moment ago, only presupposes an apparatus by which you can mine it and produce the oil from it and dump the refuse away and forget all about by-products. I don't care a continental for any of them. If they are there, we will get them when the time comes, but today it is nothing but gasoline. I believe the time is here when we are going to be working in a practical way, producing the oil from shale and turning it into gasoline and we will work the by-product when we get to it. In other words,

the business is going to work along the lines of least resistance, starting along those lines where the most economical gasoline can be procured.

CHAIRMAN ALDERSON: What do you think of the suggestion that was made here earlier in the afternoon, that in the first stages of this work, a person with a retort should turn out the crude oil, then get as much gasoline as he can and sell the rest for fuel oil?

MR. GIFFORD: I think that is the line of least resistance, and the line that we should start from. After that we will develop our by-products; but I realize this: That it is going to be very hard to raise capital. Every man that you go to for capital will say, "Well, you can't beat the oil business; the day isn't here yet. Ten years or twenty years from now we will be interested." All right, a lot of us won't be here twenty years from now, probably. Therefore, I say the day is here now, gentlemen, right here, this minute, to commence to produce oil from shale and to crack it into gasoline and the earnings from that properly used can develop whatever there may be left.

MR. EDWARDS: What percentage of shale oil can be made into gasoline by a cracking process?

MR. GIFFORD: I can only pass an opinion from some small samples of shale that I have had, but it is very easy to crack from seventy to seventy-five per cent of petroleum into gasoline, and I believe we can do absolutely as well with shale. I don't think there is any trouble whatever.

MR. BARNWELL: How do you find the quality of gasoline cracked from shale oil compares with the quality of gasoline cracked from well oil, as far as the unsaturated hydro-carbons are concerned?

MR. GIFFORD: I don't care a continental about the unsaturated hydrocarbons it contains. If they are there, we will saturate them. We will find a way, and I believe the way will be found to take care of that without any trouble. We should start with nothing else in our minds today, but to produce the shale oil cheaply, to crack it into gasoline economically, and then if we can't live out of the earnings we ought to go out of business. (Laughter.)

MR. E. L. GOTHIER: Do you think, Mr. Gifford, that the so-called coloring in the shale gasoline is any objection to the marketing of it?

MR. GIFFORD: If there is, take it out. It is a very easy matter. I saw one apparatus a short time ago that was producing very nice returns from shale oil and cracking it while doing it, producing over fifty per cent of gasoline of a yellow color.

MR. BARNWELL: How long did it stay white?

MR. GIFFORD: It was white for several days thereafter. We didn't keep it for a month. We have to mark it "quick" in that case. (Laughter.) When it comes to the question of color, the engine doesn't care a continental. It is generally some fellow on the sidewalk who thinks he knows something about it, and, because he has about a gallon, he sets himself up as an expert. You know there is a good deal of nonsense about those things. Some years ago I heard a story of two Colonels down in Kentucky, that bought between them and shared a barrel of whiskey. One of them complained it had a peculiar taste, which he described as an iron taste; the other one said, "No, it had a leather taste." They didn't seem to get anywhere and finally they decided when they emptied the barrel they would see what it was that caused the taste. When they got the barrel emptied they turned it over to find out what was in there and they found an ordinary leather covered carpet tack. (Laughter)

The engine doesn't care about the color and the exhaust will smell just the same.

CHAIRMAN ALDERSON: Have you any further questions to ask Mr. Gifford?

MR. GIFFORD: I have told you the belief that I have gathered from many years of experience in the oil business. I believe in doing it now. I believe the shale question is ripe enough to be hustled to a conclusion, when the next drop in the supply of oil comes: I don't know when it is going to be, but I do know this: That the great supply of Mexico is practically doomed, and that the great supply that has been coming into this country has been enormous. Next year we must get along with very little of it; the wells have gone to water; the great "Golden Way" as they called it, has disappeared from the face of the earth, and that is where the mass of it came from. There will be oil from Mexico for centuries to come, but not in the great flood in which it has been coming. In 1882, it was believed that the only oil in the country was that in Pennsylvania, West Virginia and eastern Ohio, and after twenty-five years there wouldn't be any more oil. So you can't tell. I don't know whether we have reached the peak or not, but I do know that bound up in the shales of this country and that can be produced by mining, there is ten thousand times more oil than has ever been burned or even taken out of the earth. It is up to the mining engineers and the retort men to get it out, so that we may use it. I don't believe it is a great problem. I think all it wants is common sense. (Applause)

CHAIRMAN ALDERSON: Mr. Gifford, have you given any particular attention to the estimates of the amount of oil available from the shales in the different states.?

MR. GIFFORD: I have read them with considerable interest. I think Mr. Barnwell would like to tell about Kentucky. Mr. Barnwell knows considerably about Kentucky, but I don't think he has looked into the ground deep enough to tell, however. I believe we are in the same boat that he is. We are just on the surface. I don't believe we know how far down God Almighty did stick that oil shale. When we stop to think of the tremendous deposits of Canada, which are all available; even on the east coast, they are immense. We know something about the Peace River country, the immense deposits of oil sands there, and they rested in peace for a long time, but they will come out some day. There is no end to it. A thousand years from now our people will still be growling about it—producing oil from shale.

CHAIRMAN ALDERSON: You might agree then, Mr. Gifford, with a statement that I made once, in Colorado, for an ordinary bed of shale: "If we had a thousand plants, each handling two thousand tons of shale a day, there was enough available shale there to last eight hundred years."

MR. GIFFORD: I wouldn't dispute it. (Laughter)

Gentlemen, we have to come to the mining of shale and somebody has to be the pioneer. Gentlemen, I am ready to do anything I know how. You only have to command me.

I thank you very much. (Applause)

CHAIRMAN ALDERSON: We are all pioneers in this game.

We have a report of the Committee on Nominations that bas not been formally acted upon.

MR. BARNWELL: Mr. Chairman, we have divided the committees into the same number we had last year, as we found we didn't need any new ones, except the Promotion Investigating Committee.

I don't see why it is, with such men as we have on these committees, that we can not get a little more action from them to report to the Conference next year than we did this year. This oil shale section is the only lever that exists in America right now to put the shale

business where it ought to be. If we don't get together and shove, what is going to happen? The chief trouble seems to be that these men are so widely scattered, geographically, that it is utterly impossible for them to get together and do any good. If there is anybody else who has some suggestions to make as to how it is possible for these committees to be of value to this National Shale Conference of the American Mining Congress, I should like to know it, because there must be some way to do it. Yesterday, we outlined some plan by which this Committee on Fraudulent Promotion can function. Of course, it it not easy to work out plans in connection with these other committees. However, there must be some way in which these committees could get something done. Mr. Wadleigh, as Chairman of the Educational Committee that I happen to be on, has gone as far as it is possible for anybody, outside of the United States Government and the Colorado School of Mines, in the publication of the Railroad Red Book, which carries a lot of new shale information.

The report of the Committee on Nominations was adopted unanimously. (See appendix.)

The Chairman then read extracts from the reports of the Committees on Education, Retorting and Refining. (See appendix for the complete reports.)

CHAIRMAN ALDERSON: There is another phase of this matter that I think ought to be pointed out before we separate. It is a view of the activities that are going on, as the men view it who are deeply interested in it and who might say they knew this oil shale region in Colorado long before any of us knew it, had seen it come from a region good enough for cowpunchers and campers to a region that is sought for by almost everybody. I wish Mr. Potter of Denver, would say something about the activities in oil shaling as he has seen them and as he sees them now.

MR. DELOS D. POTTER (Denver): Since listening to this discussion I am somewhat reminded of the five men of Hindustan, to learning much inclined, went to see the elephant, though all of them were blind. The shales are all over the country; they are different in different sections, and the problems are different in each section. For that reason, if I say anything at all, I must confine my remarks to those states in which the shale lands, until recently, have been a part of the public domain. In Colorado, Wyoming, Utah, and Nevada the oil shale lands, with but few exceptions, were Government lands. In 1915, 1916 and 1917 a great many locations were made on these oil shale lands under the placer mining law. I am not quite sure that the placer mining law was applicable to the shales at that time; however, by the terms of the Leasing Bill, locations of shales made under the placer law were recognized and it became possible to go forward with the assurance that compliance with the law would result in patents being issued to the shale lands. Since the passage of the Leasing Bill, the principal consideration of those interested in shales has been the matter of patenting lands. When operations actually begin in Colorado, Wyoming, Utah or Nevada—or in public land states—operations will be either upon privately owned lands where titles are held in fee simple, or upon lands leased from the United States under the terms of the Leasing Bill. This question of titles was discussed at length at a hearing before the Assistant Secretary of the Interior, Mr. Voglesang. There were present at this hearing Mr. Finney, now First Assistant Secretary of the Interior; Dr. George Otis Smith, Director of the Geological Survey, and Dr. Van H. Manning, Director of the Bureau of Mines, and a number of senators and representatives from the public land states. While it is generally believed in the west that those who seek to acquire public lands are always opposed by the Department, we met no such opposition, and Mr. Finney, Dr. Smith and Dr. Manning were

quite ready to co-operate, and did co-operate, with the representatives of the placer mining locations. As a result of this hearing before Mr. Voglesang, it was agreed that the development of the shale industry would be encouraged if locations made under the placer mining law were recognized and allowed to go forward to patent. It was believed that failure to recognize these placer locations would so discourage those interested in the shale development of the west that the industry would suffer a serious setback, since the shales in the public land states were thought to be the richest and should, in the nature of things, be first developed. With this end in view, these gentlemen representing the Department, co-operated with the shale men in the hearings had before the Public Lands Committee of the House and favored the recognition of the placer locations, although some doubts were entertained by a good many of us as to whether oil shale lands were really subject to location under the existing placer mining law.

During the past year more attention has been given to the patenting of lands in Colorado, Wyoming, Utah, and Nevada than to any other phase of the development of the industry and as a result, a considerable area of this land has gone to patent. Through the co-operation of the Commissioner of the General Land Office and Field Division, much has been done in working out the various problems connected with patent work, so that work of real benefit to the properties has been accomplished.

We have immense deposits of shales in these western states and many of them are very rich, perhaps the richest in the world. When our shale lands in Colorado are patented and have passed into private ownership, they will offer a basis for operations when we may test out many of the problems with which the industry is confronted. The ownership of the lands gives the assurance that, although the operators may make many errors and spend much money to little purpose, they will still have their shales, and the right to try again will not be forfeited by reason of failure to meet particular rules or regulations which might be laid down by the Government before the problems involved are well understood.

When the question of placer locations was considered at the hearings before Mr. Voglesang, and at the hearing before the Public Lands Committee in 1918, it was agreed that private enterprise would undoubtedly blaze the way by the investment of capital sufficient to determine the many problems and that from this knowledge gained through actual operations, rules and regulations for the mining and working of the shales might be intelligently determined and the question of royalties to be reserved by the government might be worked out on a practical basis. The question of royalties to be reserved to the Government is an important one. It has been estimated by some of our leading engineers that if the United States Government should finally reserve a royalty of only 1 cent per barrel on oil to be extracted from the shale lands, a 50 foot seam of the Colorado shales would net the Government $500.00 per acre. Under these conditions, it is certainly worth while to secure title to the lands and begin operations as soon as possible and as soon as economic conditions will warrant. Whenever a barrel of oil can be sold for enough money, we will see shale plants established in the fields. Many of those interested in the shales are now doing much preliminary engineering; examinations are being made in the fields and in the laboratories and much information is being compiled and correlated, so that when the time arrives that oil may be produced from shales at a profit, the work of installing plants and opening mines may go forward without delay.

It is generally recognized by those who have given the most thought to the operation of the shales that the mining, transporting, retorting, refining, and marketing of the shale products will engage a very large

amount of capital. It is believed that operations must be undertaken on a large scale, since the profits to be derived, in the beginning at least, may be measured in cents per barrel, and the ultimate success of any given enterprise may depend upon sufficient volume being attained. Production will begin as soon as oil can be produced at a profit, and with the experience gained through actual operations and better organization, profits will be increased.

In the early stages of the shale game it was thought that the profit would be much larger than it is now generally believed, and for that reason it was thought that a plant producing a few hundred barrels per day might be feasible, but it is now believed by those who have given the most thought to the subject that the mining, retorting, and refining of these products must be done on a very large scale and that large retorting plants and refineries must be installed. Some of our best engineers now believe that it is possible that retorting and refining plants may be established to treat the shale ores on a custom basis, very much as the present smelters now treat the metalliferous ores from the various mines throughout the country. It is quite within the realm of possibility that many of the smaller land owners, and even those who may take leases from the Government, can mine the shale and deliver it to custom plants that will retort, refine, and market the products. I believe there are a number of the larger concerns giving attention to this phase of the development of the industry, and that as soon as the price of petroleum has advanced sufficiently, we shall see many smaller concerns established for the mining of the shales, which will be delivered to retorting, refining, and marketing concerns. (Applause)

CHAIRMAN ALDERSON: I asked for contributions for our consideration today, and I find I have more than it would be possible to read in full. I have prepared some extracts of them. One paper is from Dean Winchester, who did the first field work for the Government, and has determined the geological age of our various deposits. His paper will appear in the printed records of the proceedings.

Mr. Burnham has contributed a paper, part of which I wish to read for your consideration, because it strikes the nail on the head.

... The Chairman read extracts from Mr. Burnham's paper ... (See appendix)

In connection with the fake promotions, Mr. Lanborn, the editor of the Chemical Age, writes to me as follows:

... The Chairman read the letter ... (See appendix)

CHAIRMAN ALDERSON: Inasmuch as these proceedings will be printed and scattered abroad, I should like to have in the record the answers to a few questions I have jotted down. My first question is: In what way can the U. S. Government best aid the oil shale industry? Dr. White. (Applause)

DR. WHITE: (Washington, D. C.) I would suggest, Dr. Alderson, that that answer might more effectively and helpfully be given by some one else who needs the help.

CHAIRMAN ALDERSON: It seems to me that means all of us. It is a very vital question, to my mind. I wish somebody would make an effort to answer it from their own point of view. What can the Government best do to help us?

MR. R. B. DENNIS: Coordinate the available information.

DR. WHITE: The greatest immediate assistance to be rendered by the Government to the oil shale people is the comprehensive and systematic testing of retort principles and designs and of methods of treating the distillates. This work should be done by the U. S. Bureau of Mines, which should have adequate and effective backing by Congress. The Geological Survey is endeavoring to assist and hopes to lead in furnishing information as to the distribution, the qualities, and char-

acteristics of the deposits. For the adequate mapping to show the distribution, stratigraphy and structure of the western oil shale deposits topographic base maps are needed. We have for several years tried to get topographic maps of areas of the richer oil shales, but our appropriations have been insufficient. They have been so meager, and the claims of the States for such work, in which they simply ask us to match funds with them, total so large as practically to consume the available money for topographic mapping by the Survey. That is one reason why we have not had more detailed mapping of the oil shale country. It is needed for the detailing of the structure and the oilbearing zones: it is needed also for the engineering construction, which must eventually be developed in that area.

CHAIRMAN ALDERSON: Dr. White, I ask the question in the kindliest spirit, but why can't the Government get things out quicker? We people who are watching all the time wait and wait and wait, until we almost lose interest.

DR. WHITE: I think you have in mind Mr. Winchester's oil shale work.

CHAIRMAN ALDERSON: All of them.

DR. WHITE: Mr. Winchester is describing the western oil shale deposits pretty thoroughly and bringing his information up to date. The delay in publication is most regrettable, due principally to the resignation of the geologist author from the service. We have also been delayed by the associated author in the bringing of the Nevada work up to date and in the revision of the bibliography. The last of the proofs have gone in, and the volume should come out in the course of the next few months.

We feel that there are a great many researches relating to oil shale which ought to be done and which we would like to do and would do if we had the money. Some of them are physical, some of them are paleontological, and some are chemical. The oil shale problem, as a research problem, before the shale comes to the retort, is purely geological. You who have been working with oil shale for many years are well aware of the great losses of money and the waste of time which have resulted from the assumption that a retort which will treat successfully one kind of shale will treat any shale. Great waste has resulted from the attempt to introduce and apply the Scotch retort. It was to have been expected. The reason why oil shales require different types of retorts and probably somewhat different modifications of the refining processes are purely geologic and have to do with the genesis of the shale, including not merely the differences in their original constituent matter and in the conditions of formation, but also the changes which the matter has subsequently endured in the course of geologic time. These changes are easily to be observed. The types and the distillates of the shales vary according to the characters and the classes and states of the ingredient matter, plus the conditions under which they were formed. The effects of geological processes in inducing chemical changes, including losses of volatile matter, are subsequently superimposed. The problems call for the detailed and thorough study of the beds in the field and for studies under the microscope and by a combination of chemical and physical experiments under the microscope, the oil shales, in the laboratory. I am fairly confident that when we have carried the study far enough, we shall be able to determine which among the various optically rather readily differentiated bodies, which compose the organic debris in the shale, break up and yield gases or oils, at one temperature, at another temperature, or at still another, and how each kind of constituent fossil residue behaves under different combinations of pressures, heat, steam, etc. When these studies have progressed sufficiently, we shall know what particular classes of the

fossil residues produce certain qualities of the oils, or certain grades of distillate.

I will illustrate this: We ought by these studies to be able to determine what classes of brown bodies, of yellow bodies, or of skins or cuticular remains, properly speaking, are first to volatilize at 450 to 550 degrees; what at 570 to 650 degrees, and so on. It takes money, but I am quite sure it can be done; and it needs to be done. We should like to know what constituents of the Elko shale give us generation of gas in the neighborhood of 550 and what at 650 degrees. This is a matter of experimental research and, as with other researches, one can not tell in advance what the results will be. I can see, however, that if this work were already accomplished, we would probably be able to tell in advance by examination with the microscope what the shales of the Green River in different areas and at different horizons would give on distillation by different processes, what processes were best suited to each shale, and, to a certain extent, how to obtain a particular type of distillate. There are, you see, two practical sides of the researches which I feel should be in progress.

A line of investigation that is very near my heart involves certain physical tests, especially sheer pressure tests with apparatus, which I am quite sure is practical, to observe the temperatures that may be developed in samples of oil shale subjected to intermittent, but drastically severe, sheering tests, running eventually into crushing tests, with such physical observations and equipment as will result in the record of the temperatures developed. These experiments relate to the theory of the origin of oil from fossil organic matter under the influence of geologic forces. It is possible that we might also develop discoveries in these experiments that would bear upon the development of better processes of oil shale retorting. These are a few, only, of the lines of needed research. Unfortunately they are time consuming and require money. I have a very disheartening reaction when I think of this work, which I hoped might be done and which ought to have been done years ago, and which I know would have been of very great dollars and cents value to the men who are now working in the field, at the retorts, and in the laboratories. I don't know whether you will get this work in time for early use or not; I am sure it will be useful later, although not of so great value perhaps as if you had it now.

This all harks back to something which I said in a recent article, and which was, in effect, twice repeated this afternoon, viz, the importance of urging every research which bears upon the possible utilization of the oil shales. These should not only be conducted by companies, they should be undertaken by everyone who is able, and they should be done in the best co operative spirit, so that any one who knows anything that will help someone else will make that information immediately available. They should go on without reference to whether oil is high or low priced. The preparation for the day when shale oil production will be both practicable and profitable in America should be advanced as rapidly as possible without regard to the price of oil. Mr. Gifford made some very cogent remarks on that subject and they ought to be taken to heart.

CHAIRMAN ALDERSON: Gentlemen, getting back to the original question, before we separate, the time is getting late, I should like to have this question directly answered for the sake of having it in the record: What can be done, practically, not theoretically but practically, to curb the fake promotion schemes? The theoretical side of it is all right, but as a practical proposition I suggest that question as to what can be done; so that before we leave we shall have some clear idea of what individually we may be able to do. That was discussed yesterday by Mr. Hankison and our resolutions cover that point in general.

MR. POTTER: Dr. Alderson, I might ask one question in answer: What can save a fool from his folly? (Laughter)

MR. RUSSELL: Doctor, you have asked rather a hard question.

CHAIRMAN ALDERSON: Of course, I have. One of the great joys some of us have in this oil shale work is that there are so many troublesome problems that we like to attack. May I answer my own question?

MR. RUSSELL: Yes sir, if you please.

CHAIRMAN ALDERSON: The answer that I had in mind is suggested by the Vigilance Committee that had been organized in New York, and is being advertised by the Magazine of Wall Street. They have a Vigilance Committee down there to keep a fool from parting with his money, and they suggest this: If you receive circulars that promise very large, inordinate returns and sure things, send them to us; just send us the circular. Then it is the business of that Vigilance Committee, if they think that proposition is irregular, illegitimate, and a fake, to turn it over to the U. S. Postal authorities for investigation and prosecution, if they think wise.

MR. RUSSELL: That is very fine. That shifts the burden of responsibility on the Government, and I think about the best we can do is to furnish information to the Government or to somebody who has real authority, against whom there will be no come back.

CHAIRMAN ALDERSON: Isn't it probable, now that with the publicity we shall give to this movement that the individual getting some of this fake stuff would know there was a committee appointed by the American Mining Congress, to whom he could send it? A committee that is informed, that knows more than he does, and would know what to do with it? That is about all our committee can do.

MR. POTTER: Mr. Chairman, it seems to me that in our part of the country, at least, we have had more trouble with people who have claimed to own shale properties, who have in fact owned no properties; perhaps have had only options or contracts, and they in turn have not known whether their possessory titles were of any value or not. It seems to me knowledge is necessary of the property which these people own, or claim to own, with some notion as to their title and with some notion as to their location, so that it might be determined whether they were really in the section of the country that had the shales. For instance, in the Green River formation we have certain parts of the territory that have rich beds, while others have merely the lower beds or those which are not of commercial value at the present moment. If there should be some question raised, for instance, it might be a very easy matter to ask for the location of these lands and the titles under which they were held. That would go a little way. As to their plan of promoting this proposition, that might be another thing; but if some one organizes a company for $14,000,000 and has ten acres of shale land and proceeds to give themselves 51% of it for promotion, we might assume that the company hardly will succeed—and some plans proposed have been almost as absurd as that.

CHAIRMAN ALDERSON: In a case like that, the man to whom the proposition was made could turn it over to the committee, and they in turn could pass it on to the U. S. Government officials who would recognize at once that the scheme was fraudulent.

MR. POTTER: It seems to me that those who want to promote some shale project might prefer to summarize the question of location, title, and their plan of financing their proposition and submit it all to the Committee of the Oil Shale Section of the Mining Congress.

CHAIRMAN ALDERSON: That committee has two good lawyers on it.

MR. POTTER: That is all right, but a great many concerns have been operating that have no titles of any kind. That is one way in which a great many losses have been occasioned. In some cases they have obtained possessory titles. They have gone on selling some stock,

and the rights which they were supposed to have in the beginning, and perhaps did have in the beginning, were diverted to the Government and were gone forever.

CHAIRMAN ALDERSON: We could name a few other cases in which the Government is now paying board and room rent for certain individuals.

MR. POTTER: It seems to me that publicity and information are essential. If the questions are asked, this committee could well in turn inquire as to the location of the properties, titles under which they are held, and their general purpose and plan of finance. They might go as far as that. If they had no replies of any kind, they might say, "We cannot report anything about them."

CHAIRMAN ALDERSON: Gentlemen, I have exhausted my list of questions; is there anything further that should be brought up?

MR. BERT L. STRINGER: Was that matter that just was mentioned by Mr. Potter definitely taken care of by a committee?

CHAIRMAN ALDERSON: Yes. Mr. Hankison of Toledo is Chairman; Mr. Waltman of Denver, Mr. Gillespie of Buffalo and Mr. Gillette of Salt Lake are members. Mr. Gillette and Mr. Hankison are lawyers.

MR. QUINN: There is one thing that must be borne in mind, of course, and that is the capital. Neither you nor any other man would go into this business today unless he could see a reasonable return, because it is a very speculative enterprise at the present time. That is a foregone conclusion. We don't know where, from a financial standpoint, it is going to wind up. If I came to you today to get you to put money into a shale proposition, you wouldn't be satisfied with five or six per cent because you could get that in bonds, taking no chances whatsoever on your money. You are taking chances in the shale proposition and I think something ought to be said on this subject. You mentioned something about exorbitant amounts. I don't think in holding out fifteen or twenty per cent on a shale proposition it could be considered exorbitant. If the business won't pay that, you will never get the capital from any source to go into it; even if it is the Standard Oil Company, unless they can see twenty per cent on their money they will not go into it, especially at this time. Where it is a speculative development, you have to offer some extra inducement. We have all been talking here today about money necessary to develop this business. We cannot simply tell them, we want the money! We must offer an inducement.

CHAIRMAN ALDERSON: I don't think you have quite the same feeling, on this matter, as these gentlemen who are objecting to fake promotions.

MR. QUINN: You mentioned high amounts, but your idea of high amounts might not be the same as mine. I think twenty per cent would be a fair proposition for this committee to consider along that line.

CHAIRMAN ALDERSON: What we had in mind for a fake promotion was something like this: I had a letter a day or two ago asking me if I knew a man by a certain name, who was in a certain eastern city, who opened up an office in a store on the main street and put up a little retort, such as we have downstairs, and made his oil and gas, and printed his stock certificates and sold them, and after he gathered in about $300,000 he locked the door and threw the key away, and we don't know where he is.

MR. QUINN: I understand; and we have fought that as hard as any one.

MR.. BARNWELL: The shale business, properly conducted, is not a speculative business. If you know exactly what it is going to cost you to get that shale out and handle it, if you know what it is going to cost, there is no speculation in it. I don't consider it a speculative enterprise in any sense of the word.

MR. POTTER: Has anybody reached that point yet?

MR. BARNWELL: I say, with those conditions known.

MR. QUINN: It happened to fall in my hands to raise the money to develop this retort that has been talked about right here. With our proposition, we have definitely told the truth about it and we have raised the money; and if we had not done that, this retort that Mr. Newbery has labored so hard to bring out and which we feel is going to be quite a contribution to the shale game would not be here today. We have it and we are running it, and, as Mr. Newbery said, anybody is welcome to come and see it. We had to go out and get that money to start it with. We did not make any such statements as that. Anybody can see it, and if it works out, and it will if it is what we think it is and what we say it is. We quite understand what you mean, doctor, and we are working body and soul on that.

MR. HANKISON: Mr. Chairman, if I may be permitted a word, I think the gentleman who just spoke has gotten exactly to the meat of the whole proposition. It doesn't make any difference to us, or the legal authorities, or anybody else, by what means people get money or for what proposition they get money, as long as they are telling the truth about it. If a man goes out and says, "I have a possessory mining claim out here that I may lose if I don't make a certain assessment payment or do certain work on it, or if I don't patent my claim within a certain time, or if I don't pay the mortgage on the property; or any other one thing, and people lay out their money upon a plain, honest statement of fact, there isn't anything in the world that this commitee or this convention can do further for them. In other words, as Mr. Potter said, you cannot save a fool from his folly, but at the same time this committee and this organization, cooperating for the good of the shale industry as a whole, can do a great many things to save a great many people a great many thousands of dollars. Likewise, it would be foolish for us to say, or to think for one minute that we would be antagonistic to any new development, such as the gentleman speaks about, of these retorts. It is clearly in my mind that the sense of this whole meeting has been that we should do everything legitimately that we can, to encourage investigation and research work both in the line of retorts and in a great many other lines that have been talked about here, in experimental mining and crushing and building of experimental plants, and in retorting and finding out the various by-products and things of that kind. That, however, cannot be done without money. Consequently, money will have to be raised for that purpose, and anything that is raised for any such purpose as that naturally could not be condemned nor the slightest suspicion or suggestion of condemnation attached to it. In other words, as I said in the beginning, as long as the truth is told about anything that induces a man to part with his money, there is no violation of law, either moral or statutory, and as long as there is no violation of law, neither this committee nor this section of the American Mining Congress can have any claim nor any censure against anybody connected with it. I think that is the entire situation. Let us tell the truth about things and let us do what we can to see that those who do things tell the truth about them, and, having done that, we have fulfilled our mission, I am sure.

CHAIRMAN ALDERSON: Is there anything further?

Before we break up, gentlemen, I should like to call your attention to the exhibit downstairs, where we have some printed matter and shale for distribution, and a laboratory sized retort in operation. I should like to have you visit it and help yourselves to anything we have for distribution.

Before we adjourn, I think I am expressing the sentiments of the officers of the Congress in thanking you for your attendance and the attention you have given these matters. If there is nothing further, we stand adjourned. The meeting adjourned sine die at 5:15 p. m.

APPENDIX

Reports of Committees

REPORT OF THE COMMITTEE ON RESOLUTIONS ADOPTED

WHEREAS, it is the desire of the Oil Shale Section of the American Mining Congress, that the development of the oil shale industry be undertaken along lines which will merit the confidence and respect of the country at large; and,

WHEREAS, the development of said industry will depend in a large degree upon the acquisition and maintenance of unquestionable titles to oil shale lands, and second, upon the solution of the problems connected with the mining and retorting of the shale and the refining and marketing of the products derived therefrom; and,

WHEREAS, the most economical and substantial development will be had through mutual cooperation and research in connection with the fundamental problems of the industry; and,

WHEREAS, fake promotion schemes have been and will continue to be a menace to the oil shale industry if permitted to exist; and,

WHEREAS, the Government of the United States can substantially aid in the solution of the various questions and problems involved in the development of the oil shale industry;

NOW THEREFORE, BE IT RESOLVED:

FIRST: That the various owners and holders of oil shale placer locations be encouraged to maintain and perfect their titles to the lands included in their said locations.

SECOND: That the Department of the Interior be urged to define specifically what character of labor and improvements shall be acceptable as annual labor, and that the Department in defining such annual labor, so define it that the work to be done will be of substantial value in the development of the property and of lasting benefit to the industry.

THIRD: That the Federal Government be urged to provide funds which will permit the Bureau of Mines and the Geological Survey to carry on and further expand research in connection with oil shales which is so vital and necessary to the forward progress of the industry.

FOURTH: That the Federal Government provide funds sufficient to permit the General Land Office to re-survey those townships in the oil shale area for which the surveys have been incomplete or confusing.

FIFTH: That every member of the Oil Shale Section, and every person interested in the welfare of oil shale, be urged to use their every effort, individually and collectively, to prevent the promotion of fake oil shale schemes by reporting all organizations of any kind entering the oil shale field to the Promotions Investigating Committee, and to assist in the prosecution of persons violating the laws and furnish all possible data to those Departments of the Government charged with the prosecution of such cases; that the Promotions Investigating Commitee be authorized to collect, receive, and dispense all data in connection with such schemes as may be reported, and said committee shall make thorough investigations based upon any such reports, and make suitable recommendations to the proper legal authorities.

REPORT OF THE COMMITTEE ON ORGANIZATION AND NOMINATIONS ADOPTED

CHAIRMAN, Victor C. Alderson, Golden, Colo.

COMMITTEES

I. EDUCATION

Frank A. Wadleigh, Equitable Bldg., Denver, Colo.
Walter Walker, Editor, "The Sentinel", Grand Junction, Colo.
S. E. Barnwell, Emery Hotel, Cincinnati, Ohio.
Anson S. Blake, Balboa Bldg., San Francisco, Calif.
Joseph Bellis, Grand Valley, Colo.

II. LEGISLATION, TITLE, AND ASSESSMENT WORK

Tyson S. Dines, 195 High St., Denver, Colo.
D. D. Potter, 605 E. & C. Bldg., Denver, Colo.
Karl C. Schuyler, First Nat. Bank Bldg., Denver, Colo.
Rea. L. Eaton, Glenwood Springs, Colo.
Robt. D. Hawley, 605 E. & C. Bldg., Denver, Colo.

III. EXPLORATION AND DEVELOPMENT

E. B. Bumsted, 908 Insurance Bldg., San Francisco, Calif.
Prof. Edw. N. Canine, East Chicago, Ind.
J. C. Howard, Utah Oil Ref. Co., Salt Lake City, Utah.
S. M. Felton, Jr., Pure Oil Co., No. 2040 S. Michigan Ave., Chicago, Ill.

IV. MINING

William C. Russell, 603 E. & C. Bldg., Denver, Colo.
H. A. Hansen, DeBeque, Colo.
R. D. Burnham, Union Oil Bldg., Los Angeles, Calif.
J. A. Ede, La Salle, Ill.

V. CRUSHING AND RETORTING

L. B. Skinner, 1070 Humboldt St., Denver, Colo.
E. J. Schraeder, Jr., Majestic Bldg., Chicago, Ill.
J. B. Jones, 523 Dwight Bldg., Kansas City, Mo.
R. M. Catlin, Franklin, N. J.
W. C. Kirkpatrick, Majestic Bldg., Chicago, Ill.
Prof. R. H. McKee, Columbia University, New York, N. Y.
J. D. Newbery, 42 Root Bldg., Buffalo, N. Y.

VI. REFINING

Dr. A. H. Low, Colorado School of Mines, Golden, Colo.
C. L. Jones, Mellon Institute, Univ. of Pitts., Pittsburgh, Pa.
E. E. Lyder, Elko, Nevada, care Catlin Shale Prod. Co.
Prof. A. J. Franks, Colorado School of Mines, Golden, Colo.
E. I. Dyer, Union Oil Bldg., Los Angeles, Calif.
R. H. Brownlee, Benedum Trees Bldg., Pittsburgh, Pa.

VII. PROMOTION AND ORGANIZATION

Col. E. D. Millikin, 506 First Nat. Bank Bldg., Denver, Colo.
Leslie H. Webb, V. P. Wedge Mech. Furnace Co., Philadelphia, Pa.
R. P. Ralston, 4th National Bank Bldg., Wichita, Kans.
F. H. Wickett, Corn Exch. Bank Bldg., Chicago, Ill.

VIII. SPECIAL ECONOMIC USES OF SHALE OIL, ITS PRODUCTS AND RESIDUE

Kirby Thomas, Rm. 704, 25 Broadway, New York, N. Y.
Gov. Emmet D. Boyle, Carson City, Nevada.
S. A. Ionides, 824 Equitable Bldg., Denver, Colo.
Otto Stalmann, 319 Ness Bldg., Salt Lake City, Utah.
Prof W. K. Kirby, Colorado School of Mines, Golden, Colo.

IX. PROMOTIONS INVESTIGATING COMMITTEE

Otto L. Hankison, 823 Ohio Bldg., Toledo, Ohio.
Wm. D. Waltman, 422 First Nat. Bank Bldg., Denver, Colo.
A. M. Gillespie, 42 Root Bldg., Buffalo, N. Y.
C. A. Gillette, Salt Lake City, Utah.

COMMITTEE ON EDUCATION

F. A. Wadleigh, Denver, Colorado, Chairman

During the past year the leading mining, metallurgical, and chemical publications, both American and foreign, as well as many of those chiefly devoted to petroleum and its products, have given much space to the problem of mining and retorting oil shale and treating the various products obtained therefrom. A vast amount of research work has been carried on by individuals and companies, as well as by the United States Bureau of Mines, the various state schools of mines, and colleges. This important work is still going forward with most beneficial results. It is with much satisfaction that your Committee is enabled to report that the "fake" exploitation of oil shale has decreased to a very marked degree, and the industry is progressing on sound business lines. The campaign of education has been conscientiously carried on, and your Committee is pleased to report satisfactory progress.

COMMITTEE ON CRUSHING AND RETORTING

Lewis B. Skinner, Denver, Colorado, Chairman

There are those who look ahead as opposed to those who live in the immediate present. Were there none of vision, we should not be enjoying countless blessings now available. Had engineers and financial interests of more recent times been unable to visualize the large asset in the copper which could be produced, the porphyries would not have been opened up; had the Anaconda Copper Mining Co. been unable to anticipate a certain state of affairs, the low grade complex ores found in its properties would not have produced 150 tons of high grade electrolytic zinc per day; had the General Electric Co. been content with its operations of two decades ago, it would not have made possible the savings due to cheaper lighting; and so on. Engineering and financing vision were responsible for these and many other accomplishments in contradistinction to many of a more obvious character. There are those who believe that there are such vast resources tied up at present in the oil shale of the Green River district of Colorado, Utah and Wyoming and of Kentucky that something should be done about making desirable products available. Such persons would resent being classed with those who are called visionary in the popular sense, or standpatters, but are proud to be called progressives.

As conceived at present, oil which may be produced from shale can only supplement the output from natural oil wells. We turn to the present oil refinery, therefore, for many of our conceptions as to what to do. This is quite proper, but should not be done exclusively, for the oil refiner has had rather simple mechanical and chemical problems to solve in that he has to handle only raw material in the liquid state and has treated hydrocarbons which are saturated in the main, and so do not present complicated chemical problems. The drilling of a well is very much standardized and the transportation and plant conveying of liquids do not demand the engineering ability that the mining of solids in large quantities, the transportation, the crushing, and the plant conveying of them do. Natural oil is readily split up into highly desirable products because of the stable character of the chemical compounds composing it, so that not nearly as intricate chemical considerations are involved in turning out useful commodities as are inherent, first, in the eduction of a liquid oil from the solid shale and, second, in refining to basic salable materials.

From the foregoing, it would appear that there is a desirability of enlisting the interest of those who have had experience in mining engineering; in conveying and crushing engineering; in mechanical engineering, for the erection and maintenance of complicated plant equipment; in metallurgical engineering, because this is the principal activity which has furnaced or otherwise treated the largest quantities of solid material; and in chemical engineering, because of the necessity of overcoming intricate problems. On account of the lowness of grade of the raw material, such expert abilities must be backed by ample financing or else a successful oil shale industry cannot be established. Because of the possibilities many processes have been suggested which hold no promise of success. It makes no difference whether patents can be obtained or not, the process conception and the equipment designing must be those which are up to the standards held as acceptable in other technological arts. How inconceivable, therefore, is it that those who have had no experience in the operations of technical plants, in designing in accord with the accepted rules of good process construction details, or have had no technological training in the principles involved, should provide successful oil shale eduction processes. The small metallic retort with readily breakable and ineffective stirring mechanisms makes its appeal to such. In our opinion, it will not provide a solution of the oil shale problem nor establish an industry. Ingenious schemes have been suggested, but your committee is uninformed as to successful outcomes resulting from attempts at plant operations. The production of crude oil has been so great and the price has been at such a low figure during the past year as to discourage the expenditure of the money necessary to proceed. Stable, successful enterprises must furnish dividends out of earnings to stockholders. Failing in this, the ventures cannot be successful, no matter how interesting the technology, how ingenious the various moves, or how well the financing may have been done.

There is an inclination on the part of some to show the "spread" between the cost of crude oil and the selling prices of some of its products and to assert that there must be a probability of success even though operating on a small scale. As to this, it should be apparent that the marketing at retail of, say, gasoline and lubricating oils costs materially just the same as does the selling of small quantities of other materials to the individual consumer. Coal, as delivered to one's cellar, is not valued as at the mine hoist, neither are any of the metals piled up at the refinery to be valued at the retail price to the fellow needing some one sheet or bar. The average consumer of gasoline and lubricants, while a member of a large horde, is small. He must therefore pay a high distribution cost. Concretely, gasoline, sold at 24 cents to the autoist, is marketed in bulk at about half as much. Now if the small independent refiner has to admit the differential (whether he thinks it just or not), just so will the oil shale process inventor have to recognize the "spread" when attempting to market, say, shale oil motor spirit. Any of us know that one of the chief considerations of present day manufacturing, where only narrow margins exist, is to see that sufficient volume of business is done to avoid the swamping of the business by overhead expense. The statisticians of several of our large mines can tell us to a ton when, at a given market price for the product, the mine would show a loss due to overhead expense which is too great for the amount of material being treated. Deducting costs as far as practicable from other industries and recognizing industrial factors of the present it would seem that a properly equipped plant, one having retort furnace units which may handle hundreds of tons a piece, and treating some 2,000 tons of shale per day in western Colorado, could only supplement the present oil industry when Mid-Continental crude is selling regularly at a minimum of some $2.50 per bbl. Turning out a few barrels per day of specialty stuff, such as might be used in flotation or the preparation of some explosive, is not

a solution of the oil shale industry, particularly when we realize the enormous tonnages of shale available and the constantly increasing and large demand for oil products.

There is no oil shale industry in the United States today, but interest should be maintained because of the enormous expenditures that will be made in a wasteful manner should we fail to attempt to anticipate requirements when the production of well oil cannot keep up to the consumption. The opinions of those in close touch with the oil business are mercurial and divergent so that no reliable estimate can be made as to when this supplementing may take place. We are all aware of the smugness with which we in the United States contemplated entering the recent world war and giving a satisfactory account of ourselves, but retrospection of the cost of unpreparedness makes us cringe even at this late day. Every company engaged to any material extent in the oil industry should have a group of high grade men, as a part of its organization, devoting time to preliminary study, to experimentation with oil shale processes and to operating toy and pilot plants, and should consider the money used in such missionary work as having been well spent. When the time is ripe, it will not be possible to select an oil shale process as one would a boiler, a filter press, or some other piece of equipment, and the company, which has not backed up a process of its own, will have to give way to the one that has.

COMMITTEE ON REFINING

Dr. Albert H. Low, Golden, Colo., Chairman

During the past year the infant oil shale industry has been in a somewhat quiescent state, owing both to financial conditions and to the low price of crude petroleum. The shale oil plants in the country are still in the experimental stage and many are at a standstill for lack of funds. With one exception there has been no production of shale oil on a commercial scale and apparently no plant efforts at refining worthy of notice. Laboratory research, however, has demonstrated that practically all the products to be obtained from crude petroleum can be refined from shale oil, and of at least as good quality, for the purposes intended, as the corresponding petroleum products. The matter of costs of such refining, on a commercial scale, is necessarily problematical, and while efforts are undoubtedly made to keep the costs low, no data can be given on this point, as the laboratory methods employed are not made public. Assurances have been received that the problem has been in a great measure solved, but further information is withheld. Your committee is of the opinion that when conditions permit the production of crude shale oil on a commercial scale, the industry will not be long retarded by the problem of successful refining.

REPORT OF THE COMMITTEE ON PROMOTION AND ORGANIZATION

Otto L. Hankison, Toledo, Ohio

The Committee on Promotion and Organization should, unquestionably, become a very important one. It should have a very definitely defined sphere of activity, if it is to accomplish the things in the minds of the men responsible for its organization.

Among the more important of the duties of this committee we may say:

FIRST, It should aid and assist in the promotion of all things that will be of material benefit to the Oil Shale Industry.

SECOND, It should aid and assist all organizations whose purpose will tend to the accomplishment of the advancement of the Oil Shale Industry.

THIRD, It should wage relentless warfare against fake promotion schemes of all kinds which effect or relate to the Oil Shale Industry.

Considering these things collectively, we may liken the Committee on Promotion and Organization to a Better Business Commission, or to any other investigating authority of a quasi public nature. We have no legalized existence. We have no right to investigate any person, firm or corporation not desiring us to so investigate, so far as the law is concerned, and considering us from the standpoint of a committee only. But we do have a right that is the right of every citizen—we can, at any time and any place, invoke the aid of the statutory law of the various states to prevent the sale of stocks, bonds, lands, or any interest in any shale proposition whatever where it is unsound or intended to defraud the public. That is every citizen's right, and while not every citizen would care so to concern himself in his neighbors' affairs, as to invoke the aid of the law, yet it should be the duty and the intent of this committee to protect the public from unscrupulous men and organizations in every way possible. It is the only thing that can be done to build up and maintain the oil shale industry. The mining industry has gone through similar situations. Even shale has had its share already and every time any section of the country is visited by one of those fake promotion propositions, the shale industry, as a whole, suffers therefrom. A legitimate proposition suffers with an illegitimate one. As we have stated, we cannot compel anyone to submit their proposition, plans, and organization, to us for comment, but we can use all legitimate means at our disposal to gain information. We can inform the public generally that if they are approached on any plans, proposition, or interested in any shale proposition, we shall be glad to obtain from them the information on the particular matter in which they may be concerned. We are then in a position to request definite information of any company, or organization, and, upon their failure to give it to us, or give us an excellent reason why it is not forthcoming, we are justified in assuming that there are things connected therewith of which they do not wish the public advised. On the other hand, good, honest, and substantial organizations would welcome the fullest investigation and the widest publicity. We should not assume to recommend, but we should assume to state facts as we find them from reliable sources and reliable records. We should not quote or give opinions, but rather let the opinions be formed from the facts that we may be able to give and let this committee do that as impartially as is humanly possible. There is no reason why this committee with the great number of reliable, competent, and well versed engineers and investigators, who are more than willing to aid us, could not be made one of the greatest instruments possible for the protection of the industry. What a Better Business Commission is to any locality, we should be to the shale industry throughout the United States, with the added advantage that instead of having investigators whose ability was measured by the meagre salaries they would receive through donations such as Business Commissions receive for their support, we should have at our disposal, and without salary requirements or compensation, unquestionably the best and most competent talent in a specialized line anywhere in the world. In conclusion, let us hope that the work initiated at the last annual Congress will be continually enlarged until the effect of our work will be such that no company of any promotive character whatsoever can hope to succeed without having itself thoroughly investigated by this Committee, and have the stamp of approval placed upon it.

Papers Presented

THE MINING OF THE OIL SHALES

by

William C. Russell

Denver, Colorado

As Chairman of the Committee on Mining of the Oil Shale Section of the Congress, it has become my pleasant duty to prepare an article upon the subject of mining for presentation to your Honorable Body. The time which I have given to it has been most agreeably spent because the subject is both interesting and fascinating, inasmuch as the mining of the oil shales and the conversion of their hydrocarbon elements into marketable products will bring into life a new and promising American industry. For such co-operation and assistance as has been rendered me by other members of the Committee in the preparation of this paper, I wish to offer my grateful acknowledgment.

MINING PROBLEMS At the outset I might say that the actual work of mining the shales will be the least of the operator's troubles, but to the engineer who has in hand the work of bringing to the surface 20,000 or 30,000 tons or more daily, there will doubtless appear many complex problems. These problems will vary in complexity, in proportion to the physical difficulties encountered underground, and to the forces which he has at his command in the way of employees and capital. Inasmuch as a daily production of 20,000 tons is taken as a premise, it is natural to suppose that the operator will be provided with the most efficient assistance, as well as the most complete equipment and labor saving devices obtainable. The mining of the shales and the production of oil therefrom will, in reality, be nothing more nor less than a large scale manufacturing enterprise, comparable, if you please, to the production of copper from our western American porphyries, where the handling of a large output at a minimum cost forms the basis of success.

COMMERCIAL OIL SHALE There are at least twenty-five states in the Union which contain oil shales of more or less value. Of these 25 states, there are only seven which, according to the classification schedule adopted by a committee of the U. S. Geological Survey, contain oil shales of a commercial value. The word "commercial", as here used, is a relative term of course, because there are really no oil shales in this country today, with the possible exception of those at Elko, Nevada, which are being mined and retorted at a profit. However, for the purpose of starting somewhere, it was necessary for the Government geologists, in their field work, to establish a basis of calculation and hence their arbitrary use of the word "commercial". While there are only seven states which have commercial shale today it seems quite possible that all twenty-five of the states falling within the government classification will ultimately be producing oil from the shales. Since I am more familiar with the deposits of Colorado than with those of any other state, and since her shales are quite as rich and quite as favorably located for economical mining as the deposits of any other state, I shall take Colorado conditions as the basis of this discussion.

EXTENT OF THE SHALE DEPOSITS According to the Government classification, there are 900,000 acres of oil shale lands in Colorado, of which about 200,000 acres are the most favorably situated for operation. The principal economic features which make this area favorable for operation, may be summarized as follows:

(1) Thickness of beds.

(2) Position of beds with reference to the horizontal.

(3) Elevation of beds above the valley floor.

(4) Faces or exposures and, hence, points of attack.

(5) The existence of many promontories or "peninsulas", camp, plant, and dump sites.

(6) Water and timber.

(7) Proximity to railroads and facility with which spur lines may be built to the properties.

A second 300,000 acres may be mined at a slightly increased cost over the first 200,000, while the remaining 400,000 acres will present more or less difficulty, chiefly because of their position in the back area and their distance from the base of supplies. A portion of this last mentioned 400,000 acres has tilted beds, which condition will add substantially to the mining cost over the first 500,000 acres, but this need not necessarily worry us for quite a while.

METHOD OF ATTACK There being no extensive open cut work possible, because of the thickness of the overburden, the mining of the shales will be carried on underground, much after the manner of mining coal—that is, by the long wall or by the room and pillar system, except in the case of the thickest strata, which may possibly be handled by the caving system. Because of the nearly horizontal position of most of the best oil shale in Colorado, and because of the long line of escarpment in which those beds are exposed, it is likely that the initial operations will be carried on through adits or tunnels. Later on, when the back area is attacked, and ventilation becomes a problem, shafts will undoubtedly be used. The average dip of the best Colorado shales embraced within the 500,000 acres mentioned in a preceding paragraph, is approximately ½ to 1° from the horizontal. This is a very fortunate stratigraphic condition, because of the facility with which haulage and drainage may be accomplished.

THE BEDS For the purposes of valuation and classification and to establish a basis for patent application, the U. S. Geological Survey has adopted a schedule of "thickness and oil content" of the shale beds. Falling within this classification there are 12 separate and distinct strata, most of which lie sufficiently far apart, one above the other, so that the mining of one stratum will not necessarily destroy the practicalbility of mining the others. Each bed, therefore, may be mined as a separate unit. These 12 beds vary in thickness from 5.5 to 49 feet, have an aggregate thickness of 154 feet, occcur within a range of 900 feet, and lie at elevations varying from 500 to 1400 feet above the valley floor. The main rich bed, or so-called "Mahogany Ledge", which extends unbrokenly through a large part of the northwestern Colorado oil shale belt, is 49 feet in thickness, is made up of 21 separate and distinct interstrata and carries, over an extensive area, 35 gallons of oil per ton. A 23.5 foot section of the 49 feet will average 45 gallons per ton and, finally, an 8.5 foot streak within the 23.5 feet will average 60 gallons per ton. The whole 49 feet, wherever we find the value as given above, has a total potential yield of 86,700 barrels of oil per acre, the 23.5 feet, 53,400 barrels per acre, and the 8.5 feet a total of 25,700 barrels per acre. The laminae, of which the 49 feet stratum is composed, vary in

thickness, color, texture, hydrocarbon elements, and potential oil content. The name "Mahogany Ledge" is purely a local term and is so used because the 8.5 foot bed mentioned as yielding 60 gallons per ton, has very much the appearance of South American mahogany. Should we propose to attack the whole 49 feet, we will recover, in mining, probably only about 65% of the total volume of shale, the balance remaining as pillars; should we open up the 23.5 foot stratum, we will recover about 75% of it, whereas, if we should mine the 8.5 foot streak we should recover 95% or better. If we remove either the 8.5 feet or the 23.5 feet, we will probably lose all or most of the balance of the 49 feet. It is here that we come to one of the interesting problems of oil shale mining, and its solution is largely a question of economy, market demands, common sense, and simple arithmetic.

UNDERGROUND MACHINERY It is probable that especially designed power drills, or a combination of auger and drill, will be used. The character of the shales in certain strata, particularly the mahogany streak, will probably admit of the use of coal cutting machines. The best shales are low in degree of hardness but are generally tough and springy. Mucking and loading machinery is desirable, especially if one of the thicker strata be mined. Maximum tonnage at a minimum cost being a desideratum, it is necessary that all of the latest and most approved drilling, cutting, loading, and transportation machinery and devices be used.

EXPLOSIVES Because of the springy, rubberlike character of the richer shales, black powder in combination with slow burning, low percentage dynamite, will probably be found the most economical and effective. Except in the case of the leaner shales where there is a large percentage of silica, high power explosives will probably not be used any more freely than they are used in hard coal mining operations. Some experimentation in the use of explosives must necessarily be carried on before the ideal combination can be reached, but it is my opinion that the use of a small quantity of high explosive to spring the hole and then the introduction of a low percentage powder for the real breaking of the ground, will be found desirable.

UNDERGROUND STORAGE There are several valid reasons why ample provision for underground storage should be made, especially where a large tonnage is being mined. Once a retorting plant is blown in, it should never stop except for repairs. In the case of a large operation there are always conditions arising which may retard progress and, consequently, all reasonable safeguards must be provided. The possibility of accidents of various kinds, such as may prevent mining for a shift or two, always threatens the operator. Therefore, there should be as much broken rock in storage as is reasonably possible. Should the mining of a stratum by the caving system be found feasible, it will be easily possible to keep well ahead of the demands, but should the room and pillar or the long wall system be used on one of the thinner strata, it will not be practical to keep any great amount of mined product ahead unless storage facilities of some kind are provided. To that end it would seem perfectly feasible to run a gangway on some one of the strata which will ultimately be mined and which lies beneath the one being attacked, put up a series of large raises to the bed above and keep them filled with broken rock. Ample underground trackage may be easily provided for as large rooms are made possible because of the generally excellent roof, while mechanically operated chute gates and automatic dump cars will assist greatly in speeding up production.

VENTILATION Ample provision should be made for underground ventilation, as there may be a certain explosive risk from dust and gases. Friction of the richer shales through the use of machine drills generates an offensive gas, which may be explosive should it collect in quantity As a partial means of preventing the generation of this gas, water may be used in drilling and cutting operations. At the present time the Government is experimenting on the combustible quality of powdered oil shale and soon some enlightening data may be looked for upon that subject. Should explosive gases, perchance, become a problem in connection with underground operations, the cost of mining will be increased in proportion to the hazard entailed. However, for a long time to come the ventilation problem will be simplified to a degree by the running of tunnels from the apices of promontories back into them, for say a mile or two, and then cross cutting in either direction to daylight. By this means, especially where the long wall system is used, ventilation should be very good without the use of fans or blowers.

HAULAGE AND TRAMWAYS Electric haulage should be used and the latest practice in handling cars to and from the tipple, such as is in vogue at our up-to-date coal and metal mines, should be applied. Surface gravity tramways, with cars of a carrying capacity of 5 to 10 tons, may be easily constructed, because there are many admirably located tram sites from a few hundred to 1500 feet in length which carry a grade not to exceed 40° from the horizontal. The valley floors are sufficiently wide at or near the lower termini of the trams to furnish ample trackage and switching space. Aerial trams seem to be out of the question for the handling of a large tonnage.

MINING COSTS At various times requests have been made of me for an estimate of oil shale mining costs, but I have been obliged to avoid committing myself because of the want of a given set of conditions, which must necessarily be had as a basis for working out a figure that would be at all reliable. Following is a list of the most important points which must be covered preliminary to estimating mining costs:

(1) Geographic location of shale bed, with particular reference to altitude, climatic conditions, base of supplies, and labor centers.

(2) Thickness of bed to be mined.

(3) Character of shale with special reference to toughness or brittleness.

(4) Thickness of overburden, in considering open cut work.

(5) Character of roof. (In considering underground work).

(6) Presence or absence of waste within the stratum to be mined.

(7) Dip or inclination of the stratum.

(8) Elevation of bed above valley floor and, hence, its position with reference to water level.

(9) The water problem.

(10) Character of entry—tunnel, slope, or shaft.

(11) Cost of labor, power, timber, and general mine supplies.

(12) Daily tonnage to be mined.

(13) Latitude as to capital investment in opening the property and the installation of labor saving machinery.

(14) Proportion of overhead which the mine must stand.

Merely as a basis for a preliminary figure. I would say that the cost of mining Colorado shale under ideal conditions should be well within the cost per ton of mining hard coal in that state. All in all, as

indicated in my introduction, the mining of the shales is the least of the operator's troubles. In itself, the laying out of a large shale mine under the most favorable of Colorado conditions, will be quite simple and the execution of the mine superintendent's plans should be carried on with such facility that he should have ample time for applying all the refinements known to the profession and thus to cut costs to a minimum, for in the mining costs alone there may be either a profit or a loss in the enterprise, at least during the early days of the industry, when a few cents a ton, one way or the other, will turn the balance.

THE OUTLOOK It appears to me quite likely that when operations shall have begun in real earnest there will be at least four classes of operators: first, those who mine, retort, refine and market; secondly, those who mine only; thirdly, those who retort only; and fourthly, those who refine and market only, each one following his particular pursuit in accordance with his own special fitness, means, and opportunity. In addition to these specialists there will be room for a large quota of research chemists and experimenters. Thus we can foresee a wide range of opportunities in this coming new business. Quite often recently I have been asked as to how soon I calculated we would be actually mining the shales and reducing oil therefrom. This has been a question impossible to answer definitely because of the ups and downs and the uncertainties of well oil production. It is significant, however, that some of the largest producers of well oil in the world are acquiring substantial acreages of oil shale land in both North and South America and are gathering much scientific data with reference to mining and treatment methods. Taking the present status of the oil industry and its outlook as the logical basis for forecasting events, all I can say is that within a very few short years it is confidently expected that we shall be producing oil from the shales, and when that time shall have arrived, I trust that it will be my privilege to appear before the American Mining Congress and, instead of telling you how we intend to mine, to explain just how it is actually being done.

WHY NOT MINING MEN AS WELL AS OIL MEN?

Roderick D. Burnham, Los Angeles, Calif.

As the old saying goes "Once a ground hog, always a ground hog", and so running true to form with my early training, I cannot help but look at the oil shale industry from the miner's viewpoint as well as from the oil man's. From our present knowledge of the behavior of oil shale as it is encountered under mining conditions, it does not seem probable that any radical change in the present day large tonnage operations will have to be resorted to. The maximum amount of overburden in the richest section of the Colorado shale fields does not exceed 500 feet in thickness. It might be well to state here that the Colorado shale beds have not been disturbed by faulting or folding since their original deposition. They lie, therefore, almost horizontal or, at most, dip ½ to 1 degree throughout the Grand Valley and DeBeque areas, and as their age is early Tertiary, they occur in a region of what might be called young topography, with long narrow canyons and nearly vertical sides or escarpments. These canyons run more or less parallel to each other toward their common drainage into the Colorado river. The upland between them is a more or less rolling plateau land, with the top 2,000 to 3,000 feet above the valley floor.

With this brief explanation as to topography, my previous statement as to the uniform thickness of overburden may be better understood, and it will be readily seen that as development progresses inward from the escarpment, ventilation can easily be obtained through shafts and

drill holes. As to how the backs or roof will hold up, or the width to which the rooms can be carried, we have not yet done enough work to demonstrate. The lean oil shale which will form the backs, is rather tough and springy and, except for slabing, I do not believe will be hard to hold up over considerable widths. The bed on which the first big work will be done is commonly known as the "Mahogany Ledge" and is about 23 feet in thickness, with an average yield of a barrel to the ton, or 53,000 barrels to the acre. This is rather too thin for caving, but by taking in a little above the mahogany ledge and a little below, an average thickness of 50 feet can be obtained that will run about 86,000 barrels per acre, and we may ultimately determine that this greater thickness of lower grade shale will be more economical to mine and easier of treatment than the 23 feet of high grade shale. The accompanying sketch, showing graphically the gallons per ton and the thickness in feet of each stratum, was taken from a portion of a vertical sample cut across the full thickness of the oil shale series (2,250 feet) on our property in Parachute Creek. Over 600 samples of the pay beds were cut along the escarpment and very uniform averages were obtained. From a close study of the beds and their relative position, one above the other, it will be seen that nearly ideal mining conditions exist. At the right of the log I have sketched a haulage system for large tonnage operations that can be used permanently for either the thin, high grade or the thick, low grade system. The bed in which the main haulage will be developed will run about 9 feet in thickness and yield about 20 gallons of oil per ton. By using this particular bed, a large part of the cost can be paid from the value of the shale removed and not have to be charged entirely to development work. You will notice that this bed lies about 60 feet below the floor of the 50 foot system and about 80 feet below the floor of the 23 foot system, leaving ample room for large ore pockets from the levels above. Such a haulage system would in no way be interfered with by any method of mining used above and, once installed, would be permanent throughout the life of the mine.

I should like here to call attention to the fact that some day we expect the oil from shales to play a very important part in the production of oil in the United States, at first in a small way but later becoming more and more important as the well oil production decreases. Our first conception should, therefore, be made with that ultimate large scale picture clearly defined in our mind, so that too much of our initial efforts will not have to be done over as we increase our production. Inasmuch as a 20,000 or 30,000 barrel per day refinery is not considered very large in the oil industry today, we will eventually come to oil shale mines that will turn out that tonnage. From the above statement it would appear that only a very few companies can operate shales successfully. This is not the case at all, for why would it not be possible for the oil companies to erect retorting and refining plants which will take the shale that is mined by other companies, each one making a profit on the product that he turns out, with the oil companies holding reserves of their own to justify them, in the first instance, for the erection of large and expensive plants? This would make it possible for many small operators to go into the purely mining end of the game, selling their shale to these plants at a price dependent upon its oil and by-product value and avoiding the large expenditures necessary for the retorting, refining and marketing machinery. This is nothing new. The mining industry years ago went through the same stages and the great custom smelters throughout the west were the result, and many a mine made money that could not afford to build its own plants. I cannot help but feel that some of the greatest opportunities in the shale industry lie along this line, and I have merely put down a few of my thoughts on paper, with the hope that others may go on from this feeble beginning.

Nothing is impossible. We only think so because we do not know just how to go about it. Nothing that amounts to much is accomplished without thought, and the opportunity for both are here.

DISTRIBUTION AND IMPORTANCE OF THE OIL SHALE DEPOSITS OF THE UNITED STATES

By Dean E. Winchester, Denver, Colorado

A great deal has been written about the oil shales of Colorado, Utah and Wyoming, considerable about the oil shales of Indiana and Kentucky, but only scattered notes regarding other occurrences throughout the United States. In the limited space allotted to this paper, therefore, I shall try to assemble all the available data regarding the distribution of oil shales and cannel coals and give a little idea of the relative importance of the different deposits. Oil yielding shales are known to exist in fully half of the states of the Union and may be present in several others, but in most of the states either the shales are too low grade or the deposits too thin or of too restricted area to make them of commercial importance. Below is given a table showing the distribution and geologic age of the principal oil yielding substances in the United States.

DISTRIBUTION OF THE OIL SHALES AND CANNEL COALS IN THE UNITED STATES

State	Geologic age	State	Geologic age
Arizona	? ?	Nevada	Tertiary
Arkansas	Devonian	New York	Devonian
Arkansas	Carboniferous	North Carolina	Triassic
Arkansas	Tertiary	Ohio	Devonian
California	Tertiary	Ohio	Carboniferous
Colorado	Cretaceous	Oklahoma	Ordovician
Colorado	Tertiary	Oklahoma	Carboniferous
Idaho	Permian	Pennsylvania	Carboniferous
Idaho	Cretaceous	South Dakota	Cretaceous
Idaho	Quaternary	Tennessee	Devonian
Illinois	Devonian	Tennessee	Carboniferous
Illinois	Carboniferous	Texas	Carboniferous
Indiana	Devonian	Texas	Cretaceous
Indiana	Carboniferous	Texas	Tertiary
Iowa	Carboniferous	Utah	Cretaceous
Kentucky	Devonian	Utah	Tertiary
Kentucky	Carboniferous	West Virginia	Carboniferous
Maryland	Cretaceous	Wisconsin	Ordovician
Missouri	Devonian	Wyoming	Permian
Missouri	Carboniferous	Wyoming	Cretaceous
Montana	Devonian	Wyoming	Tertiary
Montana	Carboniferous		
Montana	Permian		
Montana	Cretaceous		
Montana	Tertiary		

Although shales which will yield oil are to be found in nearly every geologic series from the Ordovician to the Quaternary, by far the most important deposits belong to the Tertiary of the Rocky Mountain region and the Devonian of the east central states. The deposits of northwestern Colorado, Green River formation, in average per acre richness exceed any of the other deposits so far known in the United States and probably in the world. More is known regarding the distribution, rich-

ness, and general character of the oil shales of the Rocky Mountain region than any other region, yet sufficient data are available in certain of the other more promising areas to make it possible to estimate roughly the probable amount of oil that may be taken from an acre of ground. Preliminary computations have been made for six of the more important states as follows: Note—inasmuch as the average yield of oil per acre for Colorado is the greatest this is taken as 100% and the average oil yielding capacities of shale lands in other states are compared with the average for Colorado.

APPROXIMATE RELATIVE VALUE (richness and thickness) OF THE OIL SHALES OF SIX STATES

State	Relation	Approx. Area Involved
Colorado	100%	900,000 acres
Kentucky	27%	609,686 acres
Utah	20%	2,700,000 acres
Indiana	20%	320,000 acres
Wyoming	9%	500,000 acres
Nevada	8%	1,000 acres

Locally shale deposits may, and doubtless do, have greater relative importance than is indicated by the above figures. For example the figure for Utah represents an average approximately two and a half million acres most of which area is not underlain by a great aggregate thickness of rich shale. If, however, a figure representing the average over the eastern third of the Uinta Basin only is used that figure will be at least twice the one given. Likewise if only the southern half of the area of oil shale land in northwestern Colorado is considered the average per acre richness will be greatly increased for the shales along the northern outcrop of that area are neither as rich nor as thick as those of the Grand Valley-DeBeque region to the south. The relations shown in the table are based on richness and thickness alone and do not completely represent the relative worth of shales of the different states for development purposes. In order to evaluate properly and to compare the various deposits one must also take into consideration the peculiarities of the area which influence the cost of mining and marketing the products, relations to transportation, water, etc., as well as the quantity of oil which is available from the shale. The shales in parts of Indiana and Kentucky, for example, which give an average oil yield of less than a half barrel per ton as compared to more than a barrel per ton for shales of the Grand Valley-DeBeque region of Colorado, are in a region where relatively cheap open pit mining methods may be used in winning the shale while in the Colorado area underground methods will be necessary. However, when all the influencing factors are taken into consideration the Colorado oil shale lands must be placed at the head of the list of desirable properties for development for their oil shales.

Communications by Mail

Sidney T. Jennings, President
UNITED STATES SMELTING REFINING AND MINING COMPANY
New York, N. Y.

I am very glad to know that you expect to have a representative attendance of men interested in oil shale at the convention of the American Mining Congress in Cleveland. It seems to me that the policy of this section of the American Mining Congress should be to try and obtain as much publicity as those interested are willing to allow, towards making oil shale a commercial asset. I think that the oil shale men will have to demonstrate, on a commercial scale, under what circumstances oil can be produced from shale at a profit. One of the ways of achieving this result is to get together and discuss the various difficulties that confront them. I think the providing of such a meeting is the best service that the Oil Shale Section of the American Congress can render to those interested in this industry.

Lloyd Lamborn, Editor, Chemical Age, New York, N. Y.

I trust that your plans embrace, and if not, that my suggestion is not too late for you to incorporate in the program of the oil shale meeting, a paper in which would be laid down principles that should govern the enterprise of those who incorporate and seek to sell stock in companies designed to exploit oil shale land and the wide popular interest in the industrial potentialities of oil shale. This subject, you will agree, strictly is germane to this budding industry. Its leaders should be zealous that the effort of men who are going at this thing seriously should not be embarrassed by camp followers who, in the desire to sell stock in corporations of questionable stability, are just as liable to be harmful as helpful. We all know that such enterprise plays a legitimate part in the development of industry; we all can recall successful corporations today which, in their formative period, resorted to the public for funds for development, and about which effort much at the time could be said in disparagement. What I have in mind is a paper in which would be counselled moderation and conservatism in the representations of stock sellers in their appeals to the public for funds. I think that I have said enough to make my suggestion clear, and the value of which paper in the literature of the industry I am sure you will confirm.

A. G. Canar, American Coal By-Products Co., New York, N. Y.

I am glad that the Mining Congress maintains an oil shale section. The shale industry is going to be a large one later on and will add greatly to the wealth of the country. The possibilities in shale have gripped me strongly, as it has many other technical men. But I believe in keeping my feet on the ground and viewing it not only through the spectacles of a technologist but also through the spectacles of sound business judgment. The shale industry is today only an intangible one and I can see no way that it can "arrive" until the right condition prevails in the well production of petroleum. When the total of domestic and imported supply of well oil is less than the domestic and export demand, the price of crude will go up—and when that time comes then shale oil will come into its own. I believe that the oil shale section of the Mining Congress should encourage all experimental and research

work on retorting and subsequent refining of the oil; should keep in touch with such work closely; that its big men especially should offer criticisms and suggestions in regard to research work. This should be especially applicable to men well versed in the petroleum industry, because oil shale is essentially an oil proposition. I, myself, have done some research work on shale and refining and examination of the oil. Some refining methods I developed for low temperature coal tar oils work very nicely on corresponding shale oils with only slight variation. The losses incurred are fairly small. In fact, all data that I have read of in connection with shale oil refining show losses greater than those my work obtained. It appears to me that the present types of retorts experimented with on shales have too many movable scrapers, rakes, and grates in them. The eventual type of retort which will do the work, I believe, must be a simple affair, which will continuously handle a comparatively thin layer of shale, educe all possible oil vapors therefrom, and handle a large tonnage daily. In its encouragement of research work the Mining Congress should discourage retorting apparatus which is complicated.

William Spry, Commissioner of the General Land Office, Washington

I hope that the matters now pending before the Bureau of Mines, Interior Department, will materialize so that an active campaign may be put forward particularly as it relates to the treatment of oil shales. We are patenting a number of claims out in your State and elsewhere and the interest being manifested in that resource is increasing by leaps and bounds.

Roderick D. Burnham, Los Angeles, California

I am endeavoring, in a small way, to put down some thoughts that I have had for a long time as to the future possibilities of the oil industry and asking, in a general way, why the mining men of the United States have not taken a more active interest in the oil shale industry. I feel that probably it is due to the fact that the word "oil" is connected with the word shale. They, therefore, seem to leave it entirely to the oil operators to develop this great industry. But I cannot help but feel that inasmuch as fifty per cent of the shale game is going to be mining, and mining on a large scale, that there is an opportunity for the same thing to develop in this business that developed in the mining game in our western states, and that is, the erection of custom smelters. Why would it not be possible for the oil companies to erect retorting and refining plants which will take the shale that is mined by other companies, each one making a profit on the product that he turns out, with the oil companies holding reserves of their own to justify them, in the first instance, for the erection of large and expensive plants? They would then be in a position to accept raw shale which is offered to them from other properties. This would allow many small outfits to operate the shales and make a profit and not have to undergo the enormous expense of retorting, refining, and the marketing of the products. You may think this is rather a dream on my part, but it is one that I have had ever since my first conception of the enormous industry that the shales will eventually become. As we all anticipate that shale oil will gradually and eventually replace well oil and we think nothing nowadays of a twenty to thirty thousand barrel per day refinery, I cannot help but see the magnitude of the mining operations which are going to have to be carried on when we consider that we have to mine a ton of rock for every barrel of oil.

R. M. Catlin, Franklin, New Jersey
Elko Oil Shale Products Co., Elko, Nevada.

While fully in sympathy with your efforts for the advancement of the shale oil industry and appreciating your kindly interest in our experimental work, I trust you will bear with me a little longer. You no doubt appreciate the injury that is being done to the progress of the art by premature claims of enthusiastic experimenters, to say nothing of the stock jobbing promoters' absurd statements. Sometimes one feels ashamed to admit any connection, or interest in, shale or shale oil. There are those who desire to know the real facts and, if it be possible, render available the vast resources that we know exist, as yet only as potentialities. The subject is an economic one having as you realize at best a rather small margin of profit. While it is true that our producer has started and has been run up to the rate of 144 tons a day, and at last reports had been running for eleven days (and so far as I know may still be running), we do not yet know its economical capacity. This point involves several factors. We can, no doubt, put through two or three times the tonnage with the same force on the producer, but it may not give as good products or as high a yield. These factors are not quickly determined. I have always opposed selling any products until we knew we could maintain their quantity and quality indefinitely. Of late it seemed necessary to get a practical test of our lubricating oils by unprejudiced consumers, and I consented to placing five barrels in garages with the understanding that the users should not know its source and that a careful record be kept of all the criticisms. Of course, we have tried it out on our own machines, but I realize that our boys are not apt to be impartial judges; and civic pride might influence others if they knew it was a local product. So far no adverse criticism has been reported, and the unanimity of the comments leads me to wonder if after all they don't suspect or actually know the source. I know it is a good oil so far as our tests go, but is it perfect? From the experience of years I doubt it, on general principles. So long as we run a few days and then shut down for a week to make some changes, I don't feel like claiming success. I fully expect to work out my problem, but until then do not claim anything.

John Spriestersbach, Denver, Colorado

Allow me to suggest that the matter of assessment work be taken up by the Association, requesting Congress to enact a proviso, in the mining act, to allow claim holders to pay $100.00 per claim in cash in lieu of $100.00 in assessment work, which does not help the Government or claim holders. In most instances it is merely throwing money away. If this money was paid in cash and allotted, 50% for the building of roads and highways in districts where properties are located, and 50% for the purpose of experimental plants in districts where shale lands are located, it would be doing vastly more good for the shale industry than anything so far suggested. The writer believes that 50% of all shale assessment work paid in cash would be ample to demonstrate that oil can be extracted from shale at a price to compete with oil wells and would provide for the increased demand for oil and its distillates. Should this 50% be not enough I would suggest that a part of the patent moneys might be set aside or appropriated for this work. On visits to shale districts I was very much surprised to see the vast amount of work done and money expended of no practical value, which could have been used to better advantage if expended as suggested above. Waste of time and money seem to be the motto in the oil shale fields.

Chas. E. Heller, New York, N. Y.

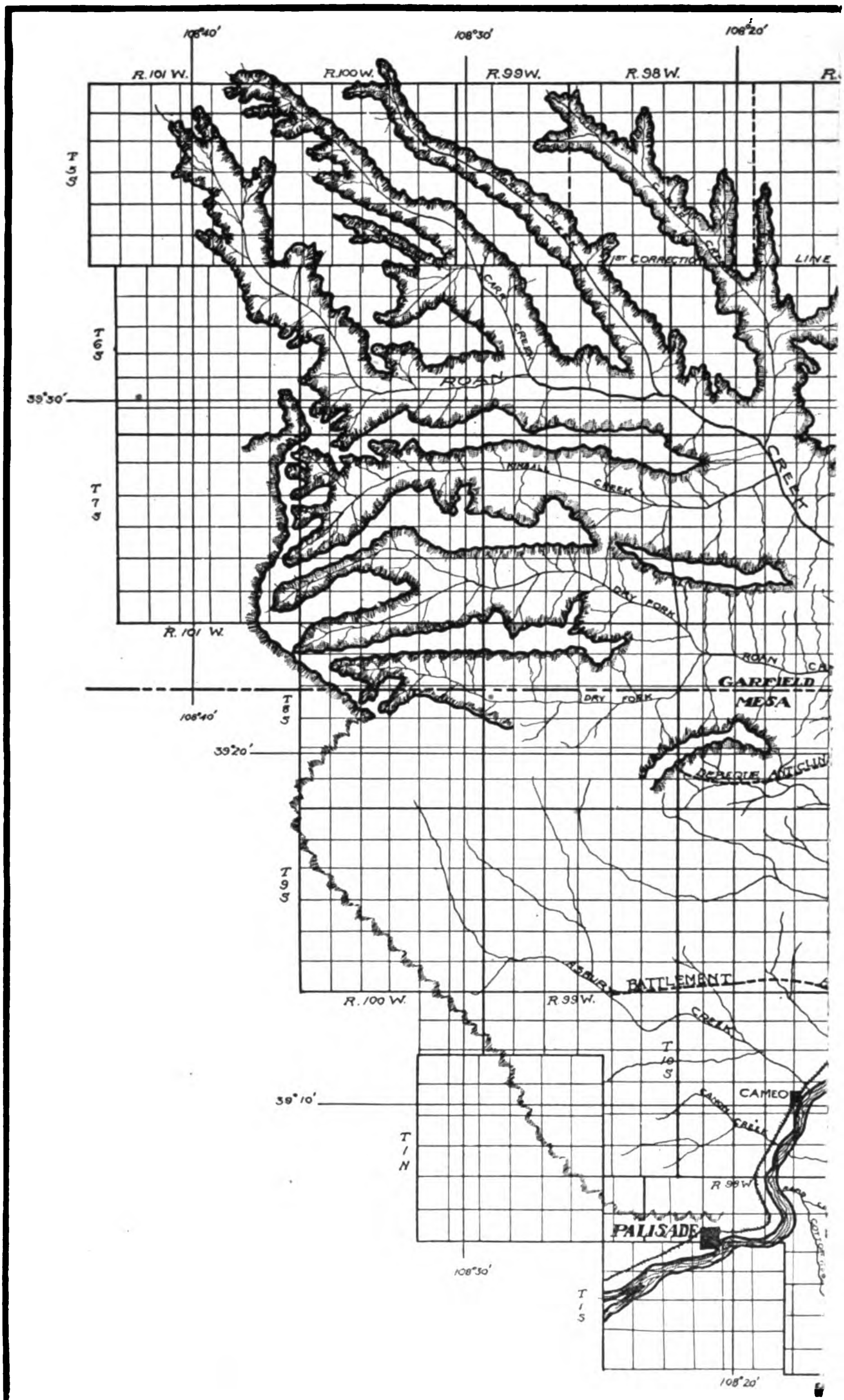
In reference to the work which should be done at the meeting, it seems to me that there is now no question whatsoever of the existence

of oil shales in very large quantities in different parts of the United States and that they contain hydrocarbons which can be distilled and condensed into valuable oils. The question of prime interest just at present is the method by which this can be accomplished and it is to this point that I would suggest that you direct the attention of the Convention. The actual facts with regard to the low heat distillation of shales and coals should be developed, tabulated, and made available.

James D. Finch, Reno, Nevada

The Department of the Interior, I understand, has recognized the validity of oil shale claims located prior to the passage of the Oil Leasing Act of February, 1920. Nevada has some very good deposits of oil shale and we have the Catlin plant at Elko in active operation producing oil of good quality. We are watching this experiment with much interest. It seems to me that the production of oils from shales will before long prove profitable to the operators and beneficial to the country, and any encouragement given the industry by the American Mining Congress will be appreciated by those of us interested financially and the country as a whole.

THE BRADFORD-ROBINSON PTG. CO., DENVER



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CREEK
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